HOUSATONIC RIVER STUDY

1980 AND 1982 INVESTIGATIONS

Volume I

FINAL REPORT

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EXECUTIVE SUMMARY

In May 1981 agreement was reached between the General Electric Company, the United States Environmental Protection Agency, and the Massachusetts Department of Environmental Quality Engineering. Pursuant to that agreement, Stewart Laboratories, Inc. conducted a study of the Housatonic River for the following:

1. Occurrence and distribution of polychlorinated biphenyls (PCBs) in the bottom sediment of the river in Massachusetts.
2. The transport of PCBs in the river system in Massachusetts.
3. PCB levels in Massachusetts fish normally used for human consumption.
4. Occurrence and distribution of PCBs in the bottom sediment of Silver Lake.
5. Fish and sediment studies in the 9-mile "no kill" area of the river in Connecticut.
6. Analysis of selected fish and sediment samples for polychlorinated dibenzofuran (PCDF).

This Housatonic River study has been completed.

The study represents a milestone in understanding the impact of PCBs in the river system and provides an in depth, integrated assessment of the environmental intrusion of PCBs into this system. Also, this study has generated a substantial body of data that provides a baseline or reference against which furture river improvement may be measured.

The purpose of this executive summary is to describe briefly the work performed and the conclusions derived from this study.

SEDIMENT

A total of 892 sediment samples were taken from the Housatonic River System in Massachusetts. The analysis of these samples indicates 39,400 pounds of PCBs adhered to the bottom and backwater sediments of the river. Of this amount 10% occurs downstream from Woods Pond Dam to the Connecticut border, 20% in Woods Pond proper, and 70% between the GE plant and the headwaters of Woods Pond. Between the GE plant and the Woods Pond headwaters, 90% of the sediments vary from fine sand to cobble size particles. Although the highest PCB levels occur in the top 6 inches of sediment, the top 2 inches have lower PCB concentrations indicating that the original deposit is being covered over. The main conclusion from this portion of the study is that the major deposits of PCBs have adhered to particles that do not move during most normal streamflow conditions and travel only limited distances during storm events. This conclusion is supported by the fact that, despite approximately forty years of usage at the GE plant followed by an additional six-year period since the discontinuation of the use of PCBs in manufacturing processes, only 10% of the PCB load in Massachusetts has passed Woods Pond Dam. The mean PCB concentration of sediments between Woods Pond Dam and the Connecticut state line is from 10 to 20 times less than the levels occurring above Woods Pond Dam.

PCB TRANSPORT

The transport of PCBs in the river was studied at three locations -- an inflow site just below Woods Pond Dam, the USGS gaging station near Great Barrington, and an outflow site near the Massachusetts/Connecticut state line. Three short-term, intensive investigations were conducted in early 1982. The three streamflow conditions studied represented typical winter background and snowmelt events, as well as a springtime high-flow period when river discharge was approximately equal to the mean annual high flow.

Three transport modes were observed in PCB movement in the river in Massachusetts. One or more of these modes may occur simultaneously; however, the predominant PCB transport mode is associated with the deposition, resuspension, and redeposition of fine-grained particles containing sorbed PCB.

This study has shown that PCB transport in the river is discontinuous and occurs only during high streamflow events. The data indicate that PCB transport at low streamflow conditions (approximately 80% of the year) is negligible. Maximum transport of PCB into Connecticut is estimated to be less than 35 pounds per year. This estimate is based on traditional statistical computations which assume PCB transport under all streamflow conditions, which may overstate PCB transport.

MASSACHUSETTS FISH

During 1980 and 1982, over 700 fish were collected from the 62-mile study area in Massachusetts.

Trout are the most effective concentrators of PCBs of all species examined. The PCB level in trout ranged from 3.3 to 240 ppm and seemed to correlate with the PCB concentration of sediment. This is in contrast to sunfish and perch which have a relatively constant level of PCBs in their tissue regardless of their river habitat. The mean PCB concentration for sunfish is 2.9 ±0.9 ppm, and for perch it is 3.3 ±1.3 ppm. Both these levels are below the FDA acceptable limit of 5 ppm in fish sold for human consumption.

Despite the fact that much of the river does not have a high density of fish species normally used for human consumption, the condition of the fish present is rated as good to excellent. Areas of the river with habitats conducive to supporting fish life have high population densities.

SILVER LAKE

The estimated load of Aroclor 1254 and Aroclor 1260 in Silver Lake is 63,600 pounds. Although the lake contains significant amounts of PCBs, discharge during the April 1982 storm event was minimal. The depth of the lake and its quiesent discharge make it an effective trap for PCBs.

CONNECTICUT FISH AND SEDIMENT

Brown trout and smallmouth bass were taken from the 9-mile "catch and release" area of the Housatonic River in Connecticut. PCBs were found in both species; however, levels in brown trout typically were higher than those found in smallmouth bass. No PCBs were detected in any of the hatchery trout used in stocking the river study area.

A definite correlation was noted between PCB levels in brown trout and fish size and length of time in the river. Composites of fish that had been in the river for 4 months and 16 months before collection contained PCB levels of 2.9 and 5.8 ppm, respectively. The average PCB level in trout is thus a function of the residence-time distribution and the data imply that it is less than 5 ppm.

Bottom sediments in the 9-mile "catch and release" area are very scattered and extremely thin and sparce. PCBs were found at two of the ten sediment sampling stations. The maximum concentration found was 120 ppb, which is considered a typical backgound level for rivers in Connecticut.

CONCLUSIONS

In conclusion, the Housatonic River Study represents an in-depth, integrated assessment of the overall magnitude of the PCB situation in the entire river system in Massachusetts. Specific areas needing further monitorng and additional study can now be defined.

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The effort and cooperation of the field and laboratory staff of Stewart Laboratories, Inc. were the key to the success of the project. However, without the capable support of MSS. Janice Sterrett, Vivian Snow, and Susan Roark, this final report would not be a reality.

ABBREVIATIONS

DEQE	Massachusetts Department of Environmental Quality Engineering
EPA	U.S. Environmental Protection Agency
FDA	U.S. Food and Drug Administration
ft^3/sec	cubic feet per second
GC/MS	Gas chromatography/mass spectrometry
GE	General Electric Company
g/m^3	grams per cubic meter (part per million)
PCB	polychlorinated biphenyl
PCDF	polychlorinated dibenzofuran
ppb	part per billion (microgram per kilogram, microgram per liter, milligram per cubic meter)
ppm	part per million (microgram per gram, milligram per liter, gram per cubic meter)
ppt	part per trillion (nanogram per liter, microgram per cubic meter)
Q_{H_2O}	water discharge
Q_{ss}	suspended solids discharge
SLI	Stewart Laboratories, Inc.
USGS	U.S. Geological Survey
$\mu g/g$	microgram per gram (ppm)
$\mu g/kg$	microgram per kilogram (ppb)
$\mu g/l$	microgram per liter (ppb)

GLOSSARY OF TERMS

Accretion - A process of sediment accumulation by flowing water.

Agglomeration - The coaslescence of dispersed suspended matter into larger flocs or particles which settle rapidly. Also called flocculation.

Aggradation - The geologic process by which stream beds, flood plains and the bottoms of other water bodies are raised in elevation by the deposition of material eroded and transported by water from other areas.

Aliquot - A fractional portion representative of the whole.

Alluvial deposit - Sediment deposited by the action of running or receding water.

Alluvial fans - A deposit of loose rock material shaped like a segment of a cone formed because of a sudden flattening of a stream gradient especially at debouchures of tributaries on main stream flood plains.

Alluvial stream - A stream whose boundary is composed of appreciable quantities of the sediments transported by the flow and which generally changes its bed forms as the rate of flow changes.

Alluviation - The process of accumulating sediment deposits at places where the flow is retarded.

Avulsion - A sudden, natural change of a stream channel, so that the water flows elsewhere than its previous course.

Bed load - Sediment that moves by saltation, rolling, or sliding on or near the streambed.

Bed material - The sediment mixture of which the bed is composed.

Centroid of equal flow - A sampling verticle which represents equal portions of stream discharge.

Clay - Sediment particles smaller than 0.004 mm in size.

Cobbles - Particles 64 to 256 mm in size.

Colloids - Finely divided solids which do not settle in a liquid. Smaller than 0.00024 mm.

Composite sample - A single sample formed by combining all the individual samples that pertain to a single sampling unit.

Contact load - Sediment particles that roll or slide along in almost continuous contact with the streambed.

Delta - A sediment deposit formed where moving water is slowed by a body of standing water.

Depth-integrated sample - A water-sediment mixture that is accumulated continuously in a sampler that moves vertically at an approximately constant transit rate between the surface and a point a few inches above the bed of a stream, and that admits the mixture at a velocity about equal to the instantaneous stream velocity at each point in the vertical. Because the sampler intake is a few inches above the sampler bottom, there is an unsampled zone a few inches deep just above the bed of the stream.

Equal-discharge-increment (EDI) method - A procedure for obtaining the discharge weighted suspended-sediment concentration of flow at a cross section whereby (1) depth integration is performed at the centers of three or more equal flow segments of the cross section and (2) a vertical transit rate is used at each sampling vertical that will provide equal sample volumes from all segments.

Filterable PCB - That PCB which is contained in the sediment-water mixture which asses through a 1.5 micron filter.

Fluvial sediment - Particles derived from rocks or biological materials which are transported by, suspended in, or deposited by streams.

Gravel - Sediment particles between 2.0 and 64 mm in size.

Lag deposits - The larger and heavier particles which are sorted out and left behind in stream channels.

Lateral accretion deposits - Sediment deposits formed along the inner (convex) sides of channel bends. See point bar.

Mean annual high flow - Average of peak discharge for years of interest.

Mean annual flood - A flood of the magnitude which has a recurrance interval of 2.3 years.

Meander - One of a series of sinuous curves, bends or loops produced in the flood plain of a mature stream.

"No kill" - Catch and relase order by the Connecticut Department of Environmental Protection.

Non-filterable PCB - That PCB which is contained in the sediment-water mixture which is retained on a 1.5 micron filter.

Oxbow Lake - Cutoff portion of meander bends.

Particle size - The diameter of a particle measured by settling, sieving, micrometric, or direct measurement methods. See scale of particle sizes.

Particle-size distribution - The relative amount of a sediment sample of a range in specific sizes in terms of percentages by weight finer than a given size.

Rating curve, sediment - A graph of the relationship betwen discharge and sediment discharge at a stream cross-section.

Ripple - Small triangular-shaped bed forms that are similar to dunes but smaller.

Runoff - That part of precipitation appearing in surface streams.

Sample take - A discrete sediment sample of a specified length, 16 cm for this study.

Sample to refusal - Collection of a sediment to the depth of the original streambed.

Sampling verticle or simply Verticle - An approximately vertical path from water surface to streambed along which samples are taken to define sediment concentration or distribution.

Sand - Sediment particles betwen 0.062 and 2 mm in size.

Scour - The enlargement of a flow section by the removal of the boundary material by the motion of the fluid.

Sediment - Particles derived from rocks or biological material which are or have been transported by water.

Sediment discharge - The quantity of sediment that is carried past any cross section of a stream in a unit of time. The discharge may be limited to certain sizes of sediment or to discharge through a specific part of the cross section.

Sediment load - The sediment that is being moved by a stream. (Load refers to the material itself and not to the quantity being moved.)

Silt - Sediment particles between sand and clay in size (0.004 to 0.062 mm).

Sloughs - A stagnant or sluggish channel of water occurring in a flood plain.

Sorting - The dynamic process by which sedimentary particles are selectively separated from associated but dissimilar particles by flowing water.

Splay - Deposits of flood debris (usually of sand) scattered on the flood plain.

Stream discharge - The quantity of natural water passing through a cross section of a stream in a unit of time. (The natural water contains both dissolved solids and sediment.)

Streamflow duration - The percentage of time during which specified daily discharges were equaled or exceeded in a given period. The sequence of daily flows is not chronological.

Supernate or Supernatant - The liquid above the surface of settled sediment.

Suspended-sediment discharge - The quantity of suspended-sediment passing through a stream cross section in a unit of time.

Suspended-sediment sampler - A sampler that collects a representative sample of the water with its suspended-sediment load.

Suspended-sediment or Suspended-load - Sediment that is supported by the upward components of turbulent currents and that stays in suspension for appreciable lengths of time.

Tape down - Measurement of distance from a standard reference point on a bridge to the water surface.

Transportation - The complex proces of moving sediment particles by water. (The principal factors affecting transportation are turbulence, ratio of settling velocity to water velocity, shape, size, density, and quantity of particles, and saltation).

Turbulence - The irregular motion of a flowing fluid.

Vertical - An approximately vertical path from water surface to streambed along which one or more samples are taken to define sediment concentration or distribution.

Vertical accretion deposits - Flood-plain deposits formed by deposition of suspended sediment from overbank flood waters.

Wash load - The portion of the stream sediment load composed of particles, usually finer than 0.062 mm, which are found only in relatively small quantities in the bed.

Water discharge - The quantity of water passing a stream cross section in a unit of time. (The native water contains both dissolved solids and sediment.) See stream discharge

Watershed - All lands enclosed by a continuous hydrologic-surface drainage divide and lying upslope from a specified point on a stream.

SECTION ONE

INTRODUCTION

1.1 Background

Up until 1980, a limited number of isolated and unrelated studies had identified polychlorinated biphenyls (PCBs) in the bottom sediments and fish population of the Housatonic River system. Since these studies were conducted by different groups using various sampling and analytical methods to fulfill a variety of study objectives, the need for an integrated, in-depth study to establish a valid PCB data base was apparent to the General Electric Company (GE). In April 1980, they commissioned Stewart Laboratories, Inc. (SLI) to design and conduct a comprehensive base-line investigation.

Specific objectives of the initial study were:

(1) to determine the distribution and concentrations of PCBs in the bottom sediments of the Housatonic River,

(2) to evaluate the mechanism of transport of PCBs within the river system, and

(3) to determine the concentration levels of PCBs in selected game fish.

The study area was the East Branch and main stem of the Housatonic River from Hinsdale, Massachusetts to the Connecticut state line, a distance of 70 river miles. The program was expanded in October 1980 to include an investigation of the distribution of PCBs in the bottom sediments of the deeper regions of Silver Lake. Silver Lake is located in Pittsfield, Massachusetts adjacent to the GE plant. Surface water drainage from the lake enters the East Branch of the Housatonic River.

Based on evaluations of field and analytical data provided by the 1980 collections, a 1981 collection program was developed to supplement the data. Additional sediment sampling sites were selected, a more specialized transport study was designed, and additional fish and other aquatic life collections were deemed appropriate. Further study expansions were integrated into the 1981 program to accommodate the requirements of the May 25, 1981 Consent Order Agreement (Docket No. 81-964) between the General Electric Company, the United States Environmental Protection Agency (EPA) and the Commonwealth of Massachusetts Department of Environmental Quality Engineering (DEQE). The original work schedule called for the follow-up field collections and the transport study to be carried out in 1981, weather conditions permitting. However, delays associated with incorporating the Consent Order modifications into the study program and with obtaining the appropriate agency approvals caused a postponement of field activities into 1982. Transport investigations were conducted from February through April 1982 and field collections occurred between June and August 1982.

1.2 Purpose and Scope

This comprehensive report, entitled "The Housatonic River Study--1980 and 1982 Investigations," is submitted in accordance with the requirements of the Consent Order. It presents the results and findings of the 1980 and 1982 programs, including supporting field and laboratory data.

The scope of the report covers all investigations performed during the past three years. Specific segments include:

(1) Initial investigations

(2) Occurrence and distribution of PCBs in bottom sediments of Housatonic River, Massachusetts

(3) PCB transport in the Housatonic River, Massachusetts

(4) PCB occurrence in game fish of the Housatonic River and selected acquatic life in Woods Pond

(5) Occurrence and distribution of PCBs in bottom sediments of Silver Lake

(6) Additional investigations required by the Consent Order:

   (a) Fish and sediment studies in the nine-mile "No-Kill" area of the Housatonic River in Connecticut

   (b) Analysis of selected fish and sediment for polychlorinated dibenzofurans (PCDF)

(7) Quality Assurance/Quality Control

(8) Summary and Conclusions

The majority of the supporting documentation, field observations, and analytical data are appended in Volume II of this report.

1.3 Study Overview

The study program, including field sampling and analysis protocols, is described in the "Housatonic River Study Proposal" submitted to the USEPA and the Massachusetts DEQE in June 1981. The overall objective of the program, as initially designed, was to establish a comprehensive, valid PCB data base suitable for comparisons with other studies or for use in future monitoring programs. After the signing of the Consent Order, additional study elements were incorporated to assure compliance with the terms of the agreement. A systematic sampling strategy was developed to provide a basic understanding of the overall

magnitude of the PCB situation in the entire river system. Based on the findings of this study, areas of concern can be defined and future monitoring needs can be determined.

1.4 Upper Housatonic River Basin

1.4.1 Basin Description.

The Housatonic River originates in northwestern Massachusetts. It is formed by the confluence of three branches in the city of Pittsfield, Massachusetts. The total watershed of the Housatonic River and its tributaries in the Commonwealth of Massachusetts covers approximately 500 square miles. A map of the study area is shown in Figure 1-1. Drainage areas of interest relating to the transport study are the station at Schweitzer bridge at Lenoxdale, 101 square miles; the USGS gaging station near Great Barrington, 280 square miles; and the station at Andrus Road bridge, 471 square miles.

1.4.2 Hydraulic Assessment.

The average annual precipitation for the study area is about 45 inches. Of that total, about 24 inches leaves the basin as overland runoff via the Housatonic River channel into Connecticut. Of the remaining precipitation, about 20 inches is lost to evapotranspiration and the remaining 2 inches infiltrates into subsurface water-bearing zones.

In addition to precipitation duration and intensity, streamflow rates are affected by temperature, elevation drops, man-made and natural structures, and tributary influxes. Municipal and industrial water-withdrawal and discharges

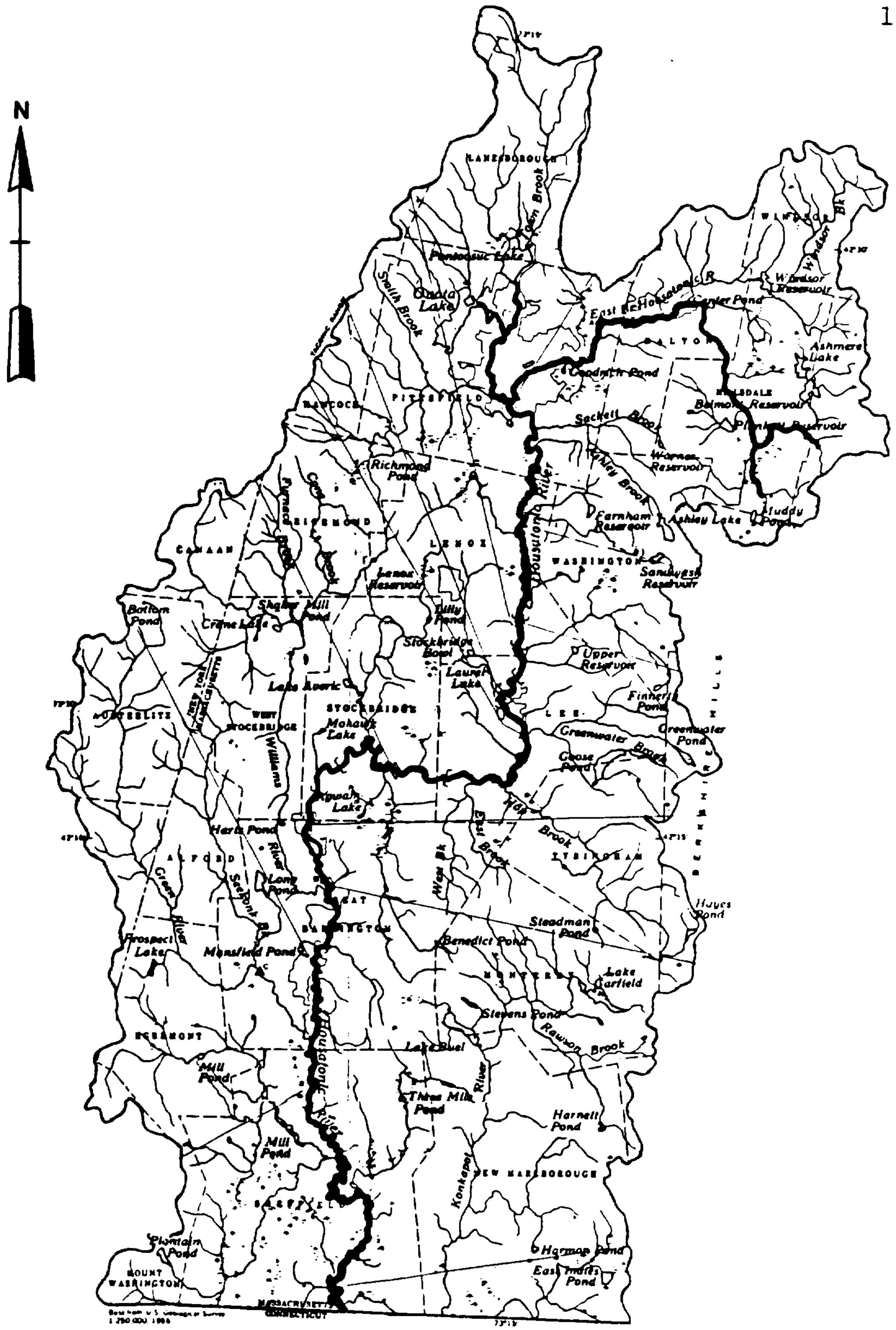


Figure 1-1
Map of Upper Housatonic River Basin

also impact the entire system. Municipal wastewater treatment plants discharge approximately 13.5 million gallons per day (MGD) into the river. An additional 17 MGD of treated wastewater is discharged into the river by industrial plants in Massachusetts. Structural features of note are dams, by-passes and meanders, oxbows, deposits at the mouths of streams entering the channel, and channel bed materials.

A graphical channel profile of the Housatonic River from its headwaters to the Connecticut state line is shown in Figure 1-2. There are three mainstream segments having distinctively different channel gradients. From the Coltsville gaging station on the East Branch to the Schweitzer bridge sampling site, a distance of approximately 13 river miles, the average channel gradient is about 4.2 feet per mile or less than 0.1 percent. The gradient between the Schweitzer bridge site and the Great Barrington gage, a distance of about 21 river miles, is 12 feet per mile or 0.2 percent. From the Great Barrington gage to the Andrus Road bridge station, the channel gradient lessens. This segment of the river channel slopes at about 2 feet per mile or 0.04 percent. Data provided by the USGS show that for the period 1961-80 the mean annual flow of the Housatonic River near Great Barrington is 529 cubic feet per second (ft^3/sec), whereas the mean annual low flow is 105 ft^3/sec and the mean annual maximum flow is 3,540 ft^3/sec. The mean annual flood at the Great Barrington gage is about 4,400 ft^3/sec. This value is not the same as the mean annual maximum, but, instead, represents a frequency interval when plotted on a Gumbel probability graph (1). The mean annual flood is defined as that event that has an expected recurrence interval of 2.3 years.

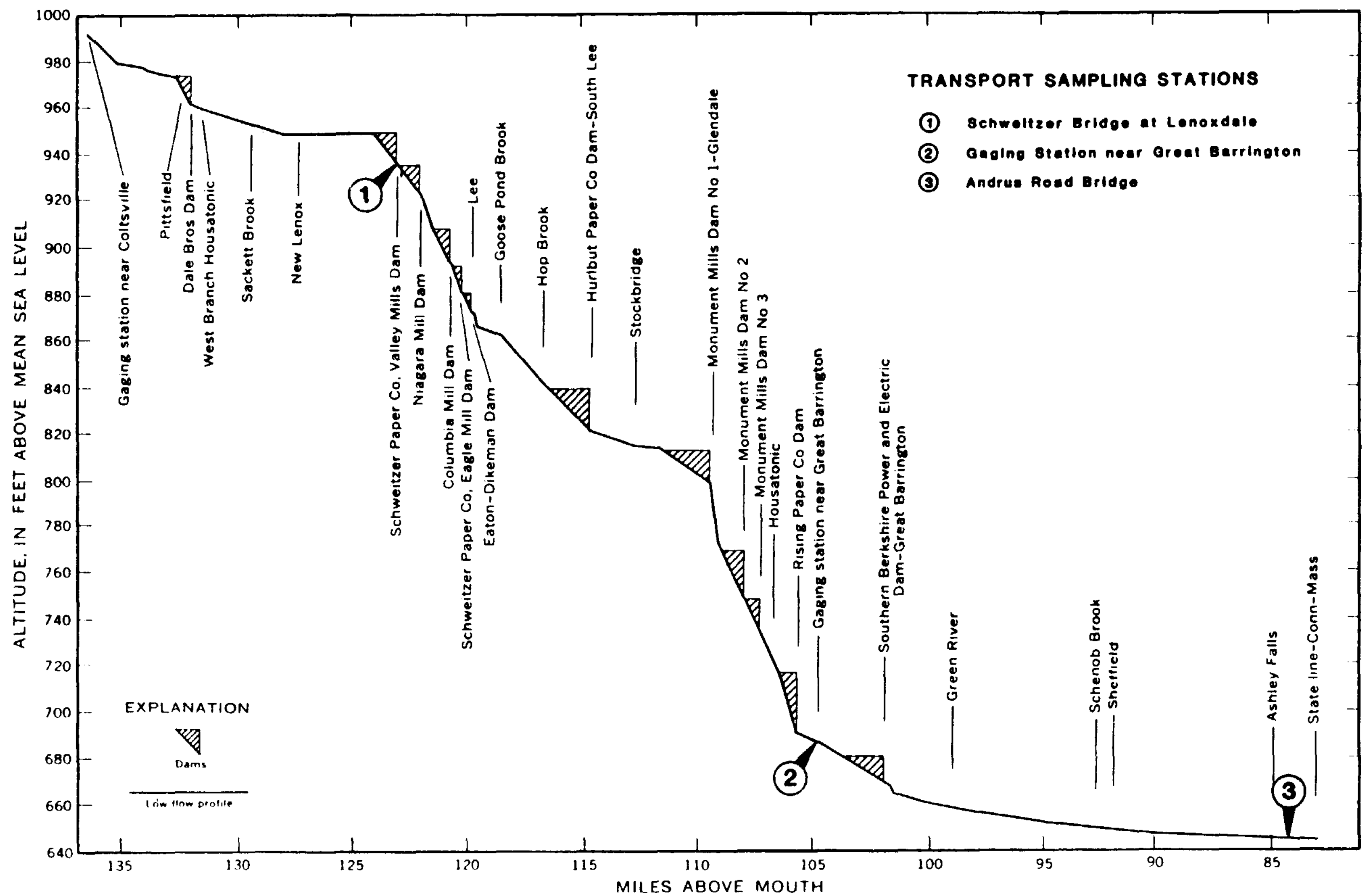


Figure 1-2
Channel Profile of the Upper Housatonic River

1.4.3 The Aquatic Ecosystem: Fauna and Habitat Types.

The Housatonic River provides a diverse mix of faunal assemblages and habitat types. From the steeper-gradient areas upstream from Schweitzer bridge to the broad meanders downstream at Andrus road bridge, a variety of stream habitats were noted. Typically, the upper segment of the river is characterized by faster flows over bedrock or riffle areas of small to large-size cobble and boulders. Interspersed among the riffles are small pools and slack-water. Sediment loads in this part of the stream are negligible compared to those found downriver.

In the transition zone around Great Barrington, the river is characterized by longer riffle areas and larger pools; bottom substrate varies from bedrock to large and small boulders with areas of shallow shifting sand. Bottom sediments (primarily sand) are more apparent than in the upper reaches of the stream and are more noticeable in the non-channel sections.

In the low-gradient segment near the Massachusetts/Connecticut line, the stream becomes more riverine with wider, slower-flowing areas. The river bottom, including part of the channel, contains more sediments including silt and clay from surrounding agricultural areas with some scattered rock.

In addition to natural flow-restricting obstructions such as uprooted trees and rocky outcrops, the river contains numerous barrier dams and diversion structures. These create additional habitat such as the relatively shallow plunge basin below the dams and the resulting tailwater areas. Of more importance are the areas impounded behind dams; these generally are inhabited by a greater diversity of fish and aquatic organisms than the riverine environment. The relative maximum flow restriction by these dams comes during periods of low flow, namely, early spring and summer. There are also numerous ground-water sources and streams entering the river throughout the entire length which serve to increase flow, volume, and sediment load.

The diversity of aquatic communities is directly related to various physical and biological parameters in the river, including water temperatures, dissolved oxygen, flow rates, and bottom substrates. Food organisms inhabiting bottom sediments and in the water column make up a significant portion of the aquatic food chain and are most important in determining the overall condition of fish populations in the river.

REFERENCE

Riggs, H.C., 1963, Frequency Curves: U.S. Geol. Survey Hydrologic Analysis and Interpretation, Book 4, Chap. A-1.

SECTION TWO

PRELIMINARY INVESTIGATIONS

2.1 Literature Review, River Reconnaisance, and Study Area Selection

Prior to field collections, available information and literature on the project area were studied (Appendix 2-1). Aerial photographs and topographic maps were used as an aid for determining sampling sites. The entire river was viewed by helicopter, and overlays of aerial photographs were used to record noteworthy observations. Numbered river markers (stakes) were installed along the river at latitude/longitude intervals of 30 seconds (Appendix 2-2). These 70 markers were located and logged by compass bearings from stationary reference points. River miles were determined by SLI employees from maps and aerial photographs (Appendix 2-3). Study areas (field stations) were selected after visiting and observing each area proposed for a given facet of the project. The exact locations and the selection rationale for field stations are included in the pertinent segments of this report. Because the emphasis of this project centered on the East Branch and main stem of the Housatonic River, the confluence effects from other waters were considered only on the basis of total influence on the study area. The existence of many elevation, structural, and source-impact characteristics of this water system required that numerous field stations be chosen for investigation. Several of these stations were segmented into substations due to physical characteristics and data evaluation requirements. Each of the stations chosen along the river system exemplified an area possessing unique qualities cognate to the project objectives. Thus, collection and measurement protocols were designed in accord with the objective of investigating PCBs in all areas of the river as they existed, with the provision for base-line comparisons in the future.

2.2 Transport Site Evaluations

Potential transport study locations were determined by visiting all bridges and measureable points of discharge (Appendix 2-4). A total of 33 sites were photographed and profiled. Stationary gages were installed at suitable locations. A system of weather prediction tracking was arranged with the University of Albany, Albany, New York; and rainfall gages were set up at USGS Coltsville (Pittsfield) and Great Barrington gaging stations. These programs were implemented during the early stages of the project and continued through 1980.

2.3 In-Depth Analysis of Selected Sediments

The first phase of analytical support for the project involved an in-depth analysis of three sediments--two upstream of Woods Pond and the third from Woods Pond itself. The objective of this investigation was to determine the concentration and identification of the individual Aroclors found in the samples. Samples were prepared as set forth in the Consent Order response. Extracts were analyzed initially by gas chromatography using electron capture detection (GC/EC). All PCB verifications and the identification of other compounds present in the samples were done by means of gas chromatography/mass spectrometry (GC/MS).

Three commercial Aroclor mixtures were identified in the samples. These were Aroclor 1242, Aroclor 1254 and Aroclor 1260. Elemental sulfur was also found to be present in sufficient quantities to cause significant interferences relative to PCB identification and analysis. Sulfur interference is frequently misinterpreted as being Aroclor 1221 or 1232. In addition to PCBs and sulfur, the samples contained the polynuclear aromatic hydrocarbons (PAHs) anthracene, pyrene and fluoranthene. The presence of the PAHs found in the Housatonic bottom sediments in conjunction with the Aroclor 1254 and 1260 present in these samples can easily be misinterpreted as Aroclor 1248. Another possible source of interference relative to the identification of Aroclor 1248 is chlorinated pesticides and their metabolites--specifically, o,p'-DDE, p,p'-DDE, and o,p'-DDT. These materials, when present in a sample, will co-elute with the primary Aroclor 1248 peaks. It is not possible, using GC/EC alone, to distinguish between Aroclor 1248 and these interfering organochlorine pesticides when they are present in the same samples.

In the analysis of environmental samples containing mixtures of commercial Aroclors, it is imperative that any alteration to the standard Aroclor patterns be viewed as suspect. Indiscriminate employment of analytical techniques based on the summation of all peaks in a given region of the chromatogram and calling it a given Aroclor will give a positive bias relative to the true PCB content of the sample.

For purposes of this program support, only chromatographic peaks verified by GC/MS to be free of interferences from materials other than PCBs were used for the analysis. This approach was applied to all sample matrices analyzed and not just to sediment alone.

It is significant to note, that although Aroclor 1248 was not found to be present in the bottom sediment of Woods Pond, Aroclor 1248 did comprise 20 percent of the PCB present in a sample of bottom sediment from Lake Lillinonah in Connecticut provided by Dr. Charles Frink, Connecticut Agriculture Experiment Station.

As mentioned earlier, three Aroclors (1242, 1254, and 1260) were determined to be present in Housatonic River bottom sediments in the state of Massachusetts. By far and away, the predominant materials present are Aroclor 1254 and Aroclor 1260. Typically, Aroclor 1242 comprised no more than 5% of the total PCB present. In order to accurately quantitate the Aroclor 1242 in the presence of much larger amounts of Aroclor 1254 and 1260, multiple injections of samples would have been required.

The relative magnitude of the environmental impact associated with the presence of the small amount of Aroclor 1242 is much less significant than the impact associated with the larger quantities of Aroclor 1254 and 1260 found in the samples. Consequently, a decision was made to quantitate and report Aroclor 1242 only if it were present in an amount ≥5% of the total PCB present in the sample. The savings resulting from this agreement permitted a substantial increase in the number of samples which could be analyzed within the analytical budget for the project. As a consequence, the sampling plan was expanded beyond its original scope to provide more detailed characterization of areas of special interest including Woods Pond and the area upstream of Woods Pond to New Lenox Road (Stations 17 & 18).

The actual Aroclor 1242 content of all samples analyzed was <5% of the total PCB present. Only Aroclor 1254 and Aroclor 1260 data were reported even though

Aroclor 1242 undoubtedly is present in small quantities in most of the samples analyzed.

2.4 Sediment Characterization.

In addition to the analysis of bottom sediments for PCB concentrations, certain sediment characterizations are required before estimates can be made relative to the mass of PCBs in the river system. Thus, data relating to particle size distribution of sediments in various parts of the river were also needed in conjunction with transport mechanism evaluations.

2.4.1 Determination of PCB Mass in Bottom Sediments.

Estimates of the total quantity of PCB in a given river site are calculated as follows: Width (meters) x Length (meters) x Average Depth at Site (meters) x Σ x Conc. PCB (g/m^3) = Mass PCB (grams) where Σ is the density factor relating PCB concentration on a dry basis to the volume of sediment.

Specific gravities were determined for selected sediment samples which represented the different sediment types encountered in the study. ASTM Method D854, "Standard Test Method for Specific Gravity of Soils", was employed for these determinations. Table 2-1 is a summary of specific gravity measurements for eight selected sediments. The appropriate density factor corresponding to the type sediment characteristics of each location was used in PCB mass calculations. These values relate to a bulk density of ~24 lbs/ft^3 for Woods Pond sediments with high organic content to ~75 lbs/ft^3 for sandy samples.

Table 2-1. SPECIFIC GRAVITY OF SEDIMENTS

Sediment Station	River Mile Location	Sample Depth (cm)	Specific Gravity
S02A	60.35	16-32	1.397
S17E9	43.84	0-16	0.623
S18ER	43.61	0-16	0.385
S18ER	43.61	0-16	0.398
S18S2	43.27	16-32	0.645
S19B	42.28	16-32	0.593
S29G3	24.34	0-16	1.195
S35C	3.57	0-16	1.162

2.4.2 Particle Size Distributions of Bottom Sediments.

Particle size determinations were made on typical samples which are representative of the sediment types present in the Housatonic River in Massachusetts. Samples were prepared and analyzed in accordance with ASTM Standard Methods D421 (Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants), D422 (Particle-Size Analysis of Soils), D1140 (Amount of Material in Soils finer than the No. 200 [75 μm] Sieve). Subsieve (<50 μm) grain sizes were calculated from Stokes' Law according to the falling velocity of the particles. The Andreasen Sedimentation Pipet technique was used for subsieve determinations. The procedure is described in Black, C. A. Editor, Methods of Soil Analysis, Part I, pp. 545-559, Am. Soc. Agronomy, Madison, WI, 1965. Representative data obtained by this technique are presented in Table 2-2.

Table 2-2. Representative Sediment Particle Size Distributions

(Results expressed as weight percent)

		Station S-36			Station S-11	Station S-18E3
		3273	3274	3275	3497	5559
Nominal Size	Microns	0-16 cm	16-32 cm	32-48 cm	0-16 cm	1-16 cm
2 - 1	2000-1000	1.25	2.26	3.58	25.88	35.86
1 - 0.5	1000-500	1.53	2.02	2.89	23.61	35.00
0.5 - 0.25	500-250	0.96	1.13	1.36	32.60	12.76
0.25 - 0.10	250-100	81.96	74.12	69.64	16.85	7.64
0.10 - 0.05	100-50	9.04	16.00	10.78	1.56	4.94
0.05 - 0.02	50-20	3.84	1.97	6.43	0.33	0.24
0.02 - 0.005	20-5	0.68	2.14	3.54	<0.05	0.79
<0.005	5	0.68	1.07	2.93	<0.05	1.34
Percent Silt and Clay		5.21	5.18	12.90	0.33	2.37

In order to simplify particle size data for evaluation purposes, the scale of sizes listed in Table 2-3 has been reduced to the following categories: sand and gravel (>62 microns), silt (4 to 62 microns), and clay (4 microns or smaller).

Table 2-3. SCALE OF SIZES FOR SEDIMENT

Size Code	Class Name	Size Standard (mm)
R	Boulder	>256
	Cobble	256 - >64
G	Pebble	64 - >4.0
	Gravel	
	Granule	4.0 - >2.0
S	Very coarse sand	2.0 - >1.0
	Coarse sand	1.0 - >0.50
	Medium sand	0.50 - >0.25
	Fine sand	0.25 - >0.12
	Very fine sand	0.125 - >0.062
M	Coarse silt	0.062 - >0.031
	Medium silt	0.031 - >0.016
	Fine silt	0.016 - >0.008
	Very fine silt	0.008 - >0.004
C	Coarse clay	0.004 - >0.0020
	Medium clay	0.0020 - >0.0010
	Fine clay	0.0010 - >0.0005
	Very fine clay	0.0005 - >0.00024
	Colloids	<0.00024
O	Mixed Organics	-

Particle size distributions were obtained for five typical sites on the Housatonic River below the GE plant and above New Lenox Road. Data obtained are summarized in Table 2-4. Greater than 90% of the sediment load in this area is medium to fine grained sand particles which are greater than 62 microns in diameter. These coarse grained sediments are not normally transported for great distances as suspended sediments at flow rates in the range observed in the Housatonic River.

Table 2-4. PARTICLE SIZE DISTRIBUTIONS
(Sites from GE Plant to New Lenox Road)

Location	PCB, ppm	Sand, %	Silt, %	Clay, %
S9E1	30.	96.	2.0	2.0
S11	210.	>99.	<1.	<1.
S12	46.	94.	3.0	3.0
S14	32.	92.	5.0	3.0
S16D	28.	91.	7.0	2.0

SECTION THREE

HOUSATONIC RIVER SEDIMENT INVESTIGATIONS

3.1 General

During 1980 and 1982, several hundred core samples were collected for analysis to determine the distribution and quantities of PCBs in Housatonic River bottom sediment. The majority of the field investigations and sample collections associated with this segment of the study were conducted between June and October 1980. Areas sampled included the heaviest bottom sediment depostions found in the river channel, impoundments, oxbows, isolated trap areas and overbanks. More detailed sampling was performed in selected areas of interest and a number of special investigations were undertaken during the summer of 1982.

Based on information gained during the initial investigation described earlier in this report (Section 2.1), 36 major sediment sampling stations were established (see Table 3-1 for station locations). These stations were divided into 226 substations covering 62 river miles from Dalton, Massachusetts to the Connecticut state line. Map locations of the sediment stations are found in Appendix 3-1.

The entire river system was methodically examined, probed, and/or sonar scanned. Substations were determined on the basis of these measurements and other more obvious conditions such as tributaries, dams, and oxbows. Within the confines of a substation, core samples were collected in locations where significant sediment was present for an area of nearly equal deposition.

Table 3.1

BOTTOM SEDIMENT STATION LOCATIONS

Sediment Station	No. of Substations	Length of Station (river miles)	East Branch Housatonic River
S1	2	0.48	Headwaters to Center Pond Dam in Dalton
S2	2	0.37	Center Pond Dam to Dam north of South Street in Dalton
S3	2	0.82	Dam north of South Street in Dalton to uppermost impounded waters of Government Mills Dam
S4	3	0.09	Government Mills Dam Impoundment
S5	1	1.58	Government Mills Dam to Penn Central Railroad Crossing at Adam's Junction
S6	1	1.55	Adam's Junction to confluence of Goodrich Pond discharge
S7	1	0.14	Goodrich Pond discharge to footbridge at Long View Terrace
S8	1	0.30	Footbridge to Newell Street bridge
S9	8	0.59	Newell Street bridge to Lyman Street bridge
S10	3	0.40	Lyman Street bridge to Elm Street bridge
S11	1	0.40	Elm Street bridge to Dawes Avenue bridge
S12	1	0.58	Dawes Avenue bridge to confluence of Southwest & West Branches
S13	1	West Branch	Confluence of SW and W branches to confluence of W and E Branches
			Main Stem Housatonic River
S14	1	0.99	Confluence of W and E branches to Holmes Road bridge
S15	1	0.76	Holmes Road bridge to pipeline crossing south of Sykes Brooks
S16	5	4.09	Pipeline crossing to New Lenox Road bridge
S17	78	4.40	New Lenox Road bridge to Headwaters of Woods Pond
S18	45	0.38	Woods Pond including by-pass and holding pond
S19	3	1.08	Woods Pond Dam to Grey Lock Street bridge in Lenoxdale
S20	10	1.28	Greylock Street bridge to Columbia Mill Dam
S21	1	1.35	Columbia Mill Dam to Stockbridge Road bridge in Lee
S22	2	0.99	Stockbridge Road bridge to Hwy. 102 Bridge south of Lee
S23	1	1.16	Hwy. 102 Bridge to confluence of Willow Brook
S24	2	0.70	Willow Brook to confluence of Hop Brook
S25	7	2.84	Hop Brook to Willow Street bridge in south Lee
S26	1	1.35	Willow Street bridge to Hwy. 7 Bridge at Stockbridge
S27	4	4.74	Hwy 7 Bridge to Dam at Glendale
S28	1	2.76	Dam at Glendale to Hwy. 183 Bridge in Housatonic
S29	20	1.11	Rising Pond Impoundment
S30	2	1.40	Rising Pond Dam to confluence of Williams River
S31	2	3.10	Williams River to Hwy. 23 Bridge in Great Barrington
S32	2	3.95	Hwy. 23 Bridge to confluence of Green River
S33	3	3.94	Green River to Boardman Street bridge in Sheffield
S34	2	4.34	Boardman St. Bridge to Loop Road off Hwy. 7 east of Silver Street north of Ashley Falls
S35	4	4.24	Loop Road to old Hwy. 7 Bridge near Bowman Hill
S36	2	2.93	Old Hwy. 7 Bridge to Massachusetts/Connecticut state line

Bottom probes were made while wading or from boats/rafts in order to determine sediment thickness. The pattern of probing was by equidistant points on a transect or grid pattern across segments of a given sampling area. Backwaters were measured in a manner consistent with preliminary findings. In impoundments the sediment was visually characterized as to layering, hardness, organic content, and general makeup. Sediment collection field data sheets for all locations sampled in 1980 and 1982 are contained in Appendix 3-2.

3.2 Sampling Program Description

3.2.1 Collections.

All collections were made with a piston sampler from inside a restraint pipe which extended above the water level. Samples were taken separately in 16 cm intervals down to refusal. Bottom samples at a core site were logged and analyzed even though they frequently represented less than a full 16 cm interval.

With the exception of large impoundments, each 16 cm core (for a given depth of sediment) was taken in triplicate and composited individually at the time of collection in the field. In large impoundments, 16 cm cores were composited in duplicate. These composite core sites were within five feet of each other in the river and in impoundments. Sample handling and quality control protocols are contained in Appendix 3-3.

3.2.2 Woods Pond Study - 1980.

Woods Pond is the first impoundment downstream of the GE plant in Pittsfield, Massachusetts. Because of its strategic location, a special study was undertaken in 1980 to totally characterize the lake as to depth of both water and sediment as well as to determine the concentration and distribution of PCB in the sediment. A special field program was designed whereby the entire impoundment was divided, with weighted buoys, in a 200-foot grid pattern (Figure 3-1). Each intersect on the grid was profiled for depth of water and hand probed for bottom sediment depths. In order to adequately characterize and properly sample the large volume and variable bottom materials in Woods Pond, it became necessary to probe many areas between the 200-foot grid intersects. A sonar device and hand held staff were used. A two-dimensional diagram of the resulting sediment profiles is shown in Figure 3-2. As a result of this study, the sampling strategy used in the Woods Pond station (S-18) was based on a clear definition of the bottom materials and depth of water so that all stations and substations represented unique regions of the pond area. Sampling station locations in Woods Pond proper are shown in Figure 3-3. Relevant findings from this study are discussed in Section 3.3.4.

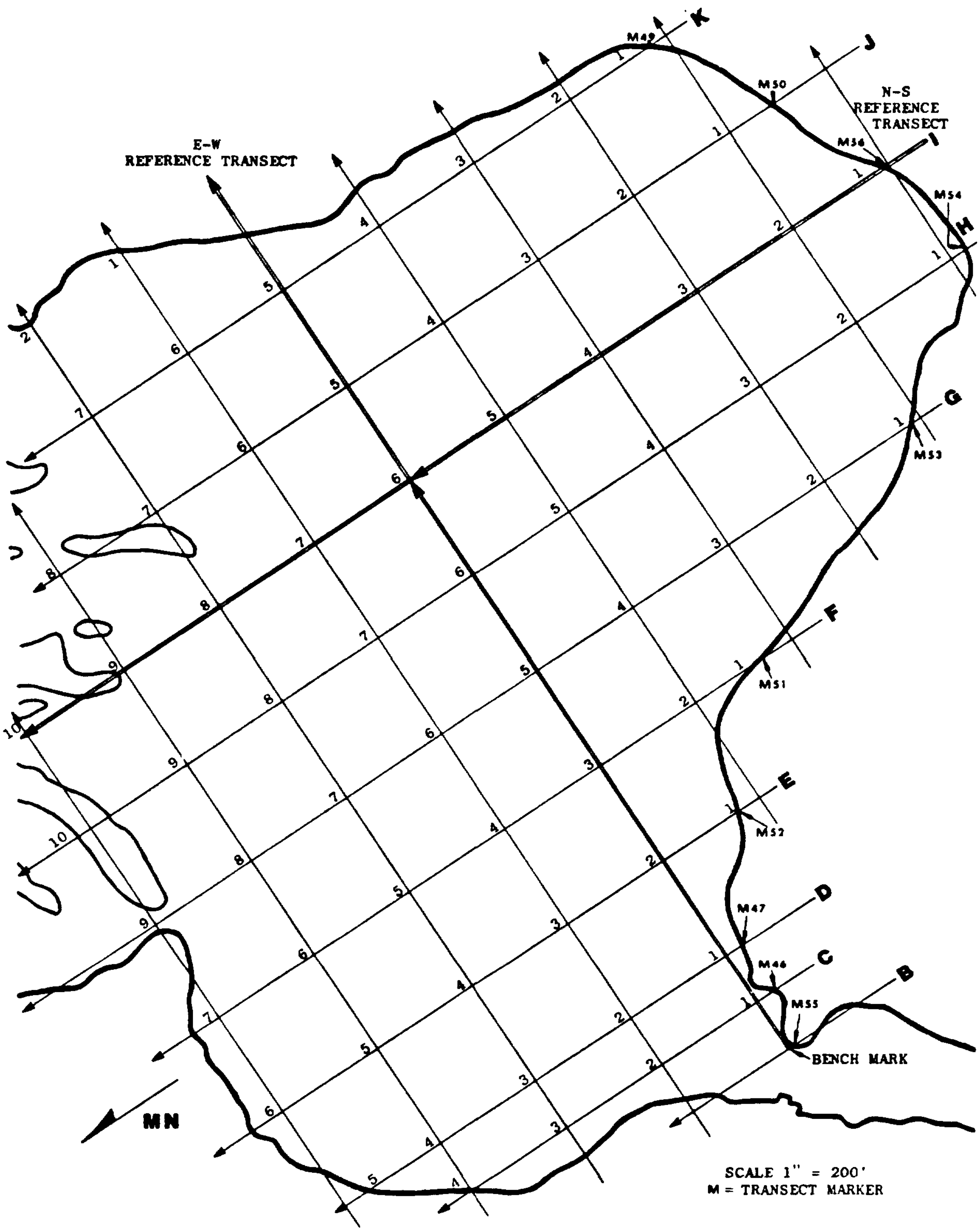


Figure 3-1
Woods Pond Reference Grid Pattern

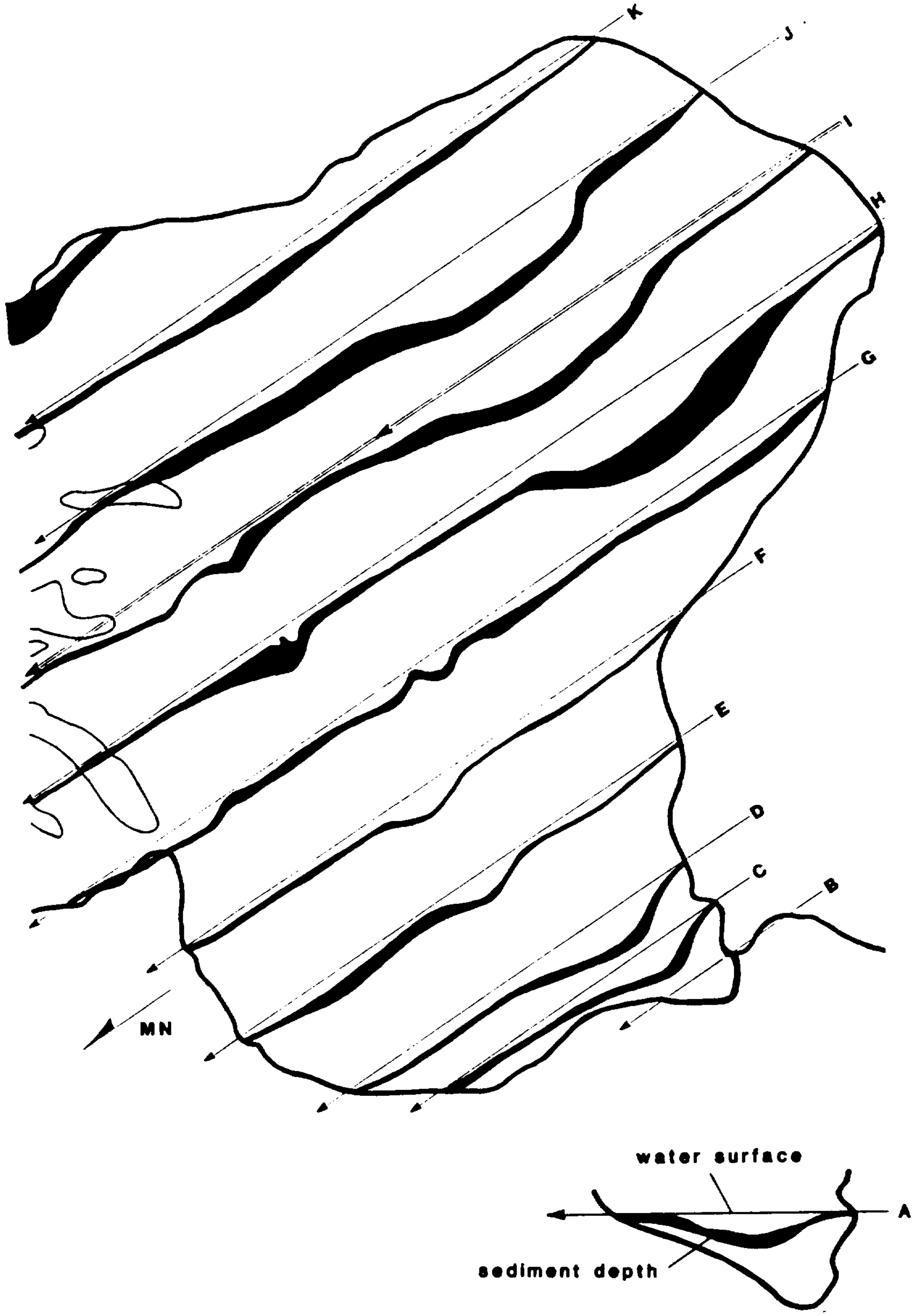


Figure 3-2
Depth Profiles, Woods Pond

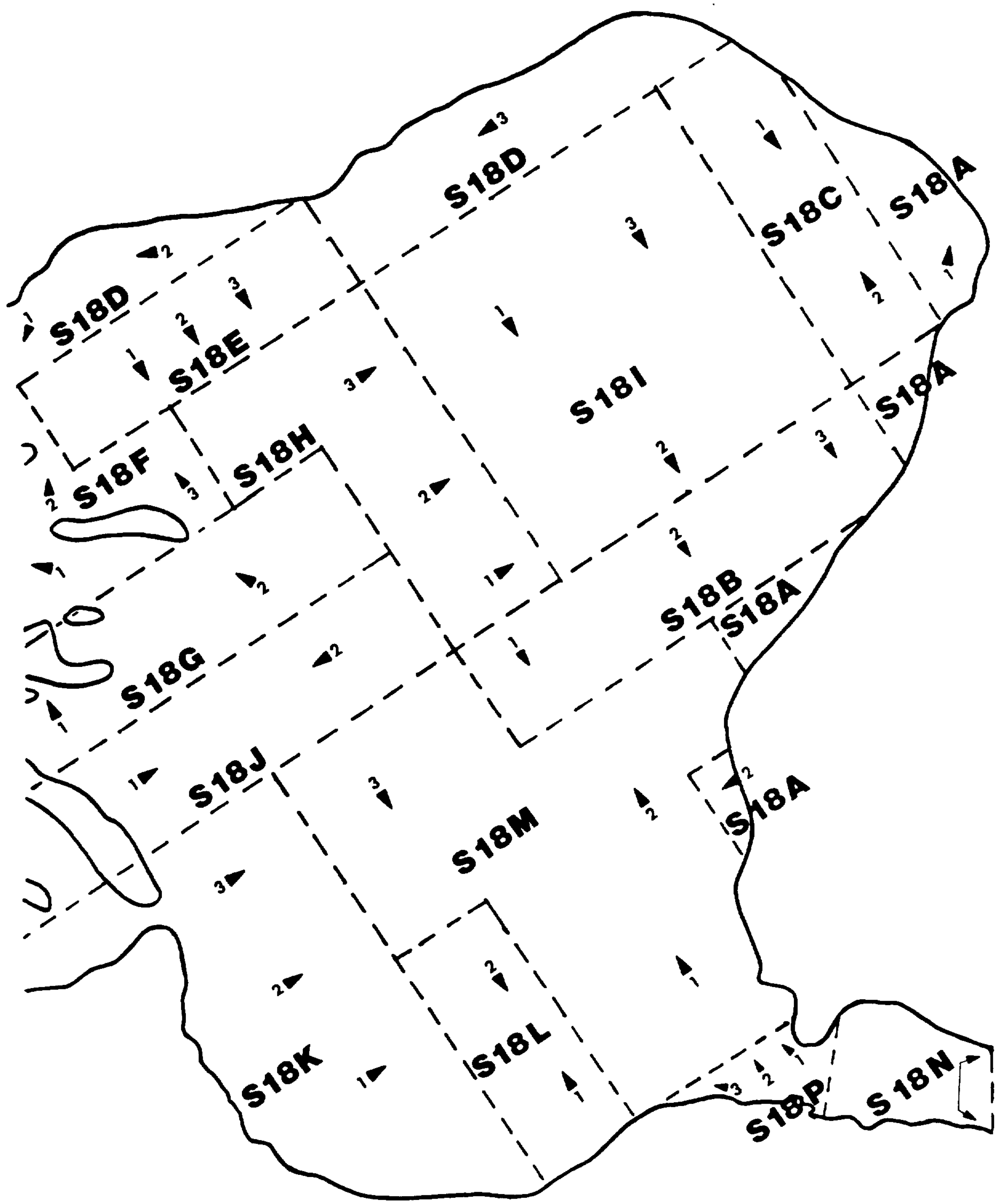


Figure 3-3
Woods Pond Sediment Sample Substations

3.2.3 Woods Pond Studies - 1982.

Four special studies were performed in Woods Pond in 1982. Two were designed to determine the reliability and reproducibility of the 1980 study. The third investigation was a field quality control core replication study, and the fourth was implemented to determine if "silting over" was occurring in the vicinity of Woods Pond. Results of the first three studies duplicated the findings of the 1980 Woods Pond study. Study details and results for these three investigations are appended (Appendix 3-4). Details of the fourth study are given below.

3.2.3.1 Two Inch Sampling Increment Study

The purpose of this study was to determine to what degree "silting over" was occurring in Stations 17 and 18. Two areas, known to contain sediments with elevated PCB concentrations, were selected. The locations of these sampling sites are shown in Figure 3-4. Results for the four sites, which were sampled in duplicate, are plotted in Figure 3-5. It is significant to note that in all cases the total PCB concentration in the top two-inch increment of the core is the lowest of any of the samples in the study. Implications of these findings will be discussed in Section 3.4.

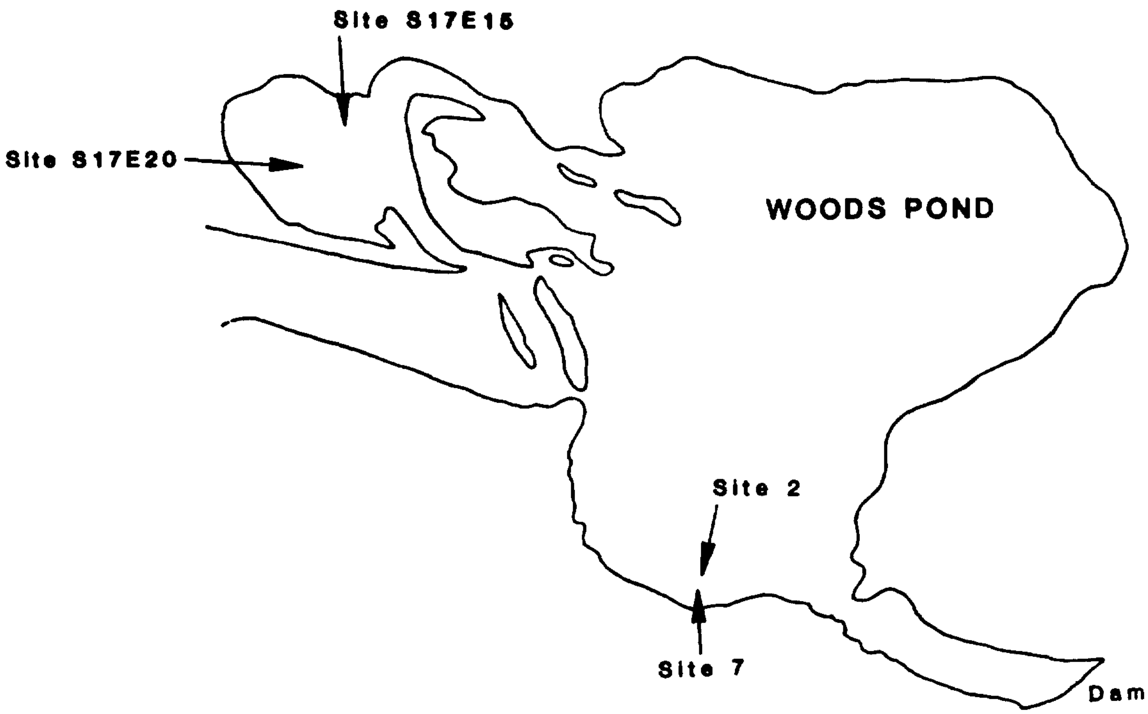
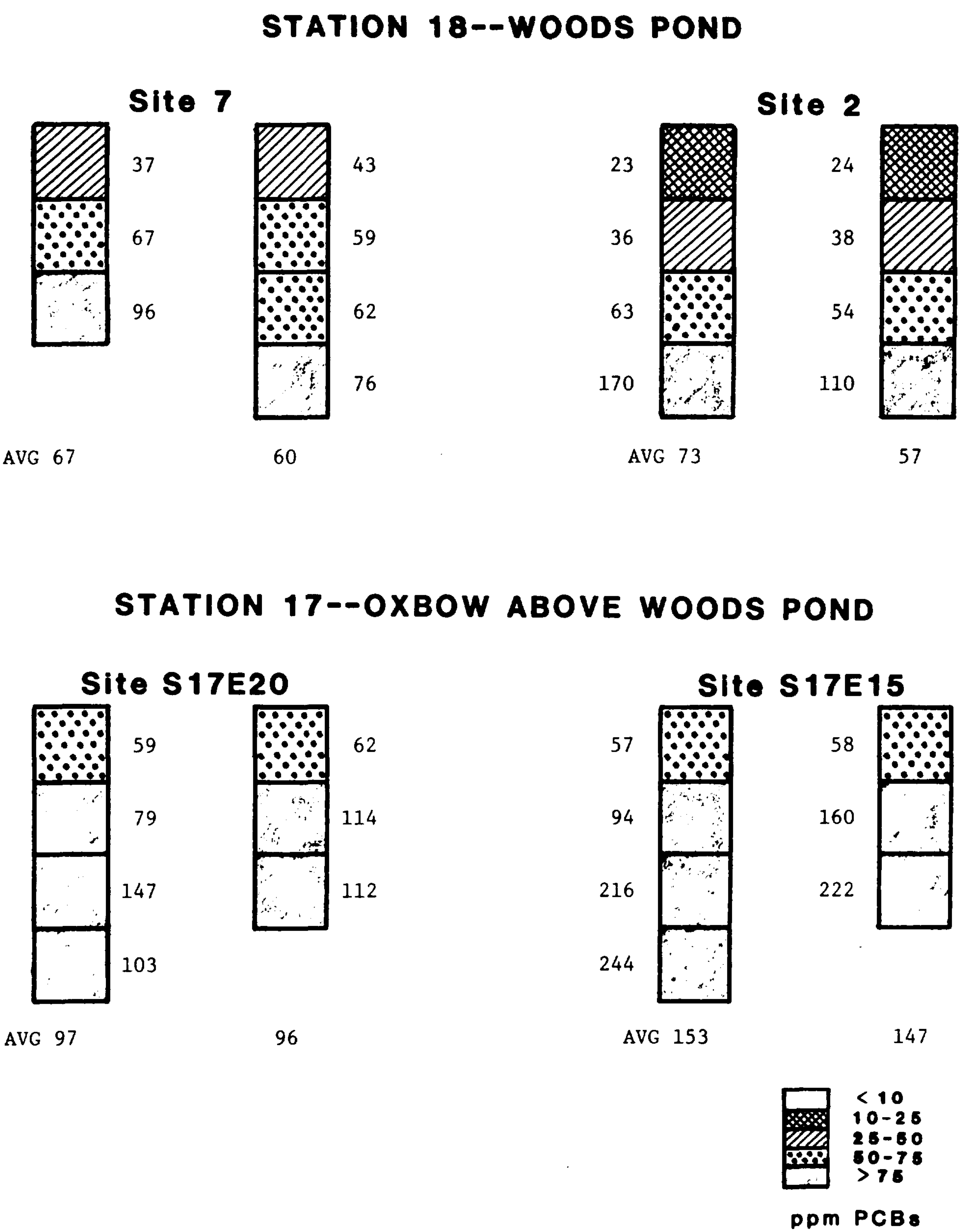


Figure 3-4
Two-Inch Increment Study Sampling Locations

Figure 3-5
TWO-INCH INCREMENT STUDY



3.3 Distribution of PCBs in Housatonic River Bottom Sediments

The May 26, 1981 Consent Order requires the identification of all locations in which bottom sediments of the river are likely to contain concentrations of PCBs at or above a level of 1 ppm. To this end, a total of 892 bottom sediment samples, exclusive of special investigations and quality control are contained in Appendix 3-5. In keeping with the Consent Order requirement relative to measurement of contaminants in all sediments, all PCB results are expressed as parts per million (mg/kg) Aroclors on a dry sediment basis. The computer printout also gives the exact sampling locations within each sediment station, date of collection, depth of core takes and depth of water. Analytical results for PCBs are reported as concentration Aroclor 1254, Aroclor 1260, and as total PCBs. Unless specifically noted, discussions relative to concentrations and locations refer to total PCBs present at a given site.

The locations and concentrations of total PCBs in bottom sediments along the complete 62 mile study area are shown in Figure 3-6. With this overview in mind, the study area can be divided into six convenient units for purposes of discussions and data evaluations. These units are:

(1) Sediment Stations S1 - S8 and Station S13, the river upstream of the GE plant and a station on the West Branch;

(2) Stations S9 - S12 and S14 - S16, the river between the GE plant and New Lenox Road bridge;

(3) Station S17, the river between New Lenox Road bridge and Woods Pond;

(4) Station S18, Woods Pond including the by-pass and holding pond.

(5) Stations S19 - S29, the river from below Woods Pond Dam to Rising Pond Dam;

(6) Stations S30 - S36, the river from below Rising Pond Dam to the Conncecticut state line.

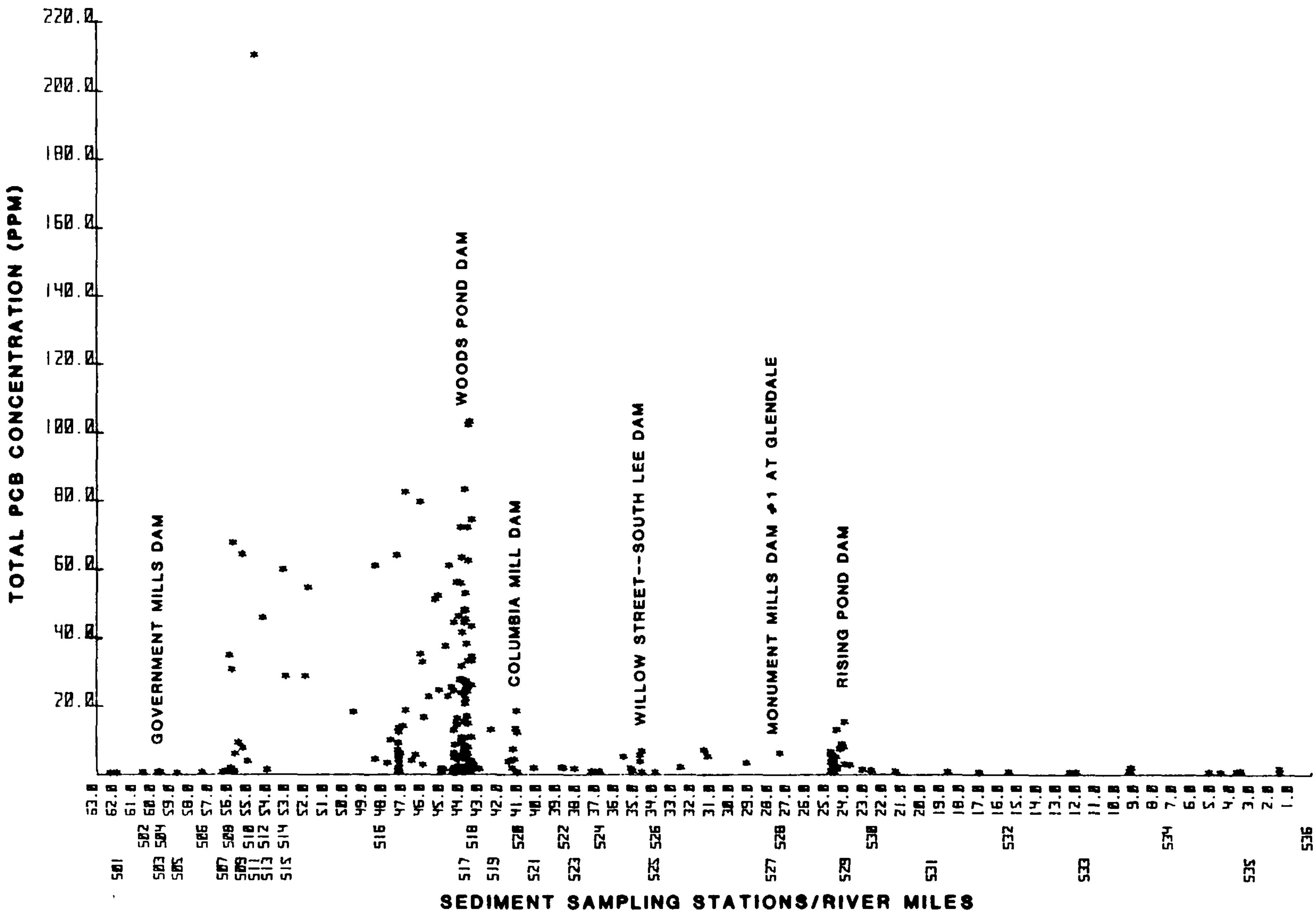


Figure 3-6
Total PCB Concentration Versus River Mile

3.3.1 Sediment Stations S1 - S8 and S13.

These stations all contain PCB concentrations of less than 1 ppm. The mean PCB concentration level for this study area is 0.15 ppm. The confluence of Unkamet Brook and the East Branch of the Housatonic River is in Station 5 at river mile 57.90. There is no evidence to indicate that discharge from Unkamet Brook has contributed appreciably to the contamination of the bottom sediments of the Housatonic River. A summary of PCB concentration by stations for this river unit is found in Table 3-2. The calculated PCB load for this 6.33 mile reach of river is 14 pounds.

Table 3-2. PCB Concentration in Stations S1-S8 and S13

Station	Total PCB Concentration (ppm)
S1	None Detected
S2	0.03
S3	0.02
S4	0.03
S5	None Detected
S6	0.21
S7	0.24
S8	0.57
S13	0.91

3.3.2 Sediment Stations S9-S12 and S14-S16.

This river unit is 7.8 miles long, covering the area from the GE plant to New Lenox Road bridge. The river is basically shallow over bedrock, cobbles, and coarse sand with pronounced turbulence in Stations S9-S12. Some sand bars and sediment deposition areas are present although sediment deposition is classified as minimal to moderate.

Station S11 represents a unique area only ~2,000 feet in length. There is a swirled backwater area with obvious deposition much like a sand bar. The area is apparently an effective trap. Sediments of Stations S9-S12 are primarily coarse grained with very little silt and clay. The average PCB concentration for these four stations is 75 ppm. The river in Stations 14-16 is characterized by meanders surrounded by oxbow lakes, sloughs, splay and vertical accretion deposits. There is heavy leaf burden in trap areas, and sediment deposition is moderate. Sediments are essentially medium to fine sands with less than 10% silt and clay. These three stations have a mean PCB concentration of 41 ppm. The total unit, stations S9-S12 and S14-S16, has a mean PCB concentration of 60 ppm. Data for individual stations are found in Table 3-3.

Table 3-3. PCB Concentration in Stations S9-S12 and S14-S16

Station	Total PCB Concentration (ppm)	Total PCBs (pounds)
S9	18.	160
S10	25.	260
S11	210.	1070
S12	46.	290
S14	60.	910
S15	28.	1080
S16	36.	4740

A summary of PCB distribution in this unit of river follows in Table 3-4.

Table 3-4. Mass and Distribution of PCBs for Stations S9-S12 and S14-S16

Station	Length (river miles)	Avg.Depth (cm)	% PCB (0-32cm)	Pounds PCB (0-32cm)	Pounds PCB Total
S9-S12, S14-S15	3.72	37	90.	3400.	3700
S16	4.09	51	69.	3270.	4740

This 7.81 mile reach of river has a calculated PCB load of 8510 pounds, of which 78% (6670 pounds) is contained in the top 12 inches of sediment.

3.3.3. Station S17.

This station covers 4.40 river miles and extends from New Lenox Road bridge to the headwaters of Woods Pond. It is characterized as a wetland floodplain with significant backwater areas. For the most part, the river meanders and stream banks are not well defined. Deposition of sediment is pronounced in backwater areas, and aquatic plant growth is profuse. Data from the 1980 collections showed this station to be the principal repository for PCBs in the Housatonic River. Because of the significance of this finding, further sampling of the area was conducted in 1982. In all, 78 sites were sampled in Station 17. A map of the station (Figure 3-7) gives sampling site locations. Data summaries for backwater areas and the river are given in Tables 3-5 and 3-6. The mean concentration of PCBs in Station 17 is 22 ppm, with average levels for backwater and river sediment of 16 and 25 ppm, respectively.

The calculated PCB load is 19,500 pounds, with 13,000 pounds in the backwaters and 6,500 pounds in the river. The top foot of sediment contains 95% of the PCB load in the river bottom sediments. In the backwaters, 87% of the PCB load is in the top foot. The backwater area of Station 17 is estimated to be 520 acres.

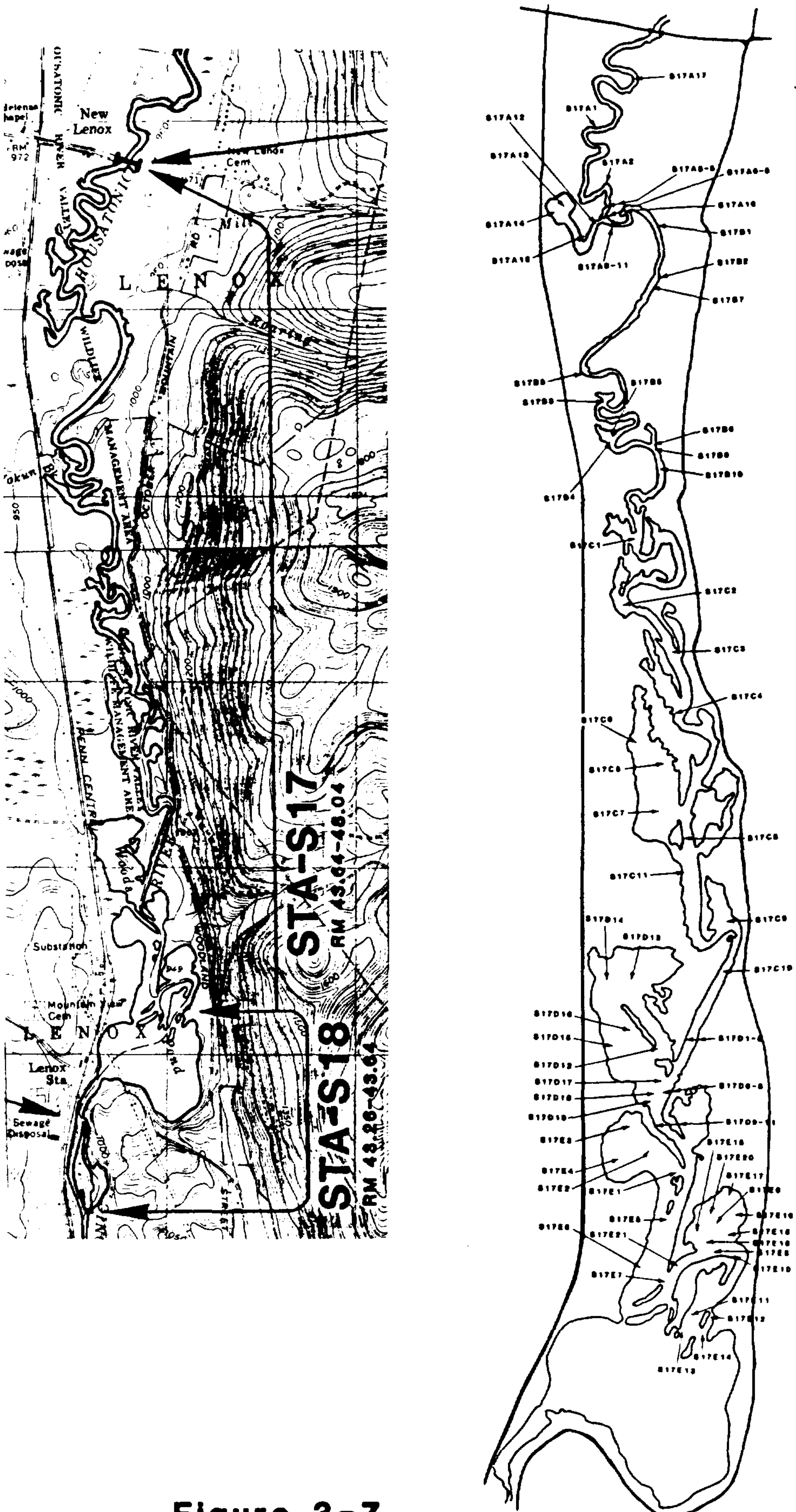


Figure 3-7

Station 17-New Lenox Road Bridge to Headwaters of Woods Pond

Table 3-5. **STATION 17 RIVER SAMPLING SITES**

Site No.	Sediment Depth (cm)	Total PCB (ppm)	% of Total (0-32cm)
17A1	64	9.6	54.
17A2	142	64.	11.
17A3	14	0.51	100.
17A4	24	3.8	100.
17A5	14	6.7	100.
17A6	10	13.	100.
17A7	16	1.1	100.
17A8	16	1.1	100.
17A9	48	0.35	97.
17A10	74	12.	67.
17A11	24	2.5	100.
17A16	48	5.6	89.
17A17	24	4.7	100.
17B1	80	14.	68.
17B2	64	82.	62.
17B3	128	5.1	94.
17B4	54	79.	97.
17B5	111	35.	48.
17B6	72	32.	89.
17B7	40	40.	49.
17B8	34	5.1	100.
17B9	24	3.7	100.
17B10	22	32.	100.
17C1	110	22.	51.
17C2	126	51.	47.
17C3	106	52.	45.
17C4	128	24.	25.
17C9	90	61.	64.
17C10	16	25.	100.
17C11	96	78.	80.
17D1	62	4.5	76.
17D2	64	13.	98.
17D3	12	44.	100.
17D4	96	24.	86.
17D5	54	0.91	96.
17D6	72	0.05	86.
17D7	12	8.2	100.
17D8	16	1.5	100.
17D9	48	0.14	26.
17D10	15	0.04	100.
17D11	112	14.	46.
17E5	80	55.	66.
17E6	64	41.	94.
17E7	32	1.6	100.
17E8	96	63.	45.
17E10	64	27.	94.
17E11	112	44.	67.
17E12	64	12.	99.
17E13	95	52.	81.
17E14	95	21.	92.
17E21	80	82.	42.

Table 3-6. STATION 17 BACKWATER SAMPLING SITES

Site No.	Sediment Depth (cm)	Total PCB (ppm)	% of Total (0-32cm)	Estimated Area(acres)
17A12	58	8.7	99.	63
17A13	64	4.7	99.	
17A14	48	0.18	88.	
17A15	42	5.1	93.	
17C5	24	1.2	100.	110
17C6	24	0.41	100.	
17C7	62	1.0	80.	
17C8	32	37.	100.	
17D12	24	5.8	100.	234
17D13	80	0.40	59.	
17D14	16	0.04	100.	
17D15	16	0.92	100.	
17D16	32	0.25	100.	
17D17	15	0.50	100.	
17D18	28	0.54	100.	
17D19	112	56.	39.	
17E1	64	46.	90.	72
17E2	32	4.0	100.	
17E3	64	16.	96.	
17E4	32	1.9	100.	
17E9	128	72.	48.	41
17E15	48	62.	100.	
17E16	80.	27.	91.	
17E17	80	31.	75.	
17E18	16	4.9	100.	
17E19	32	0.85	100.	
17E20	64	58.	91.	

3.3.4 Station 18.

This station is Woods Pond, the first impoundment downstream of Pittsfield, Massachusetts. The station is 0.4 river mile in length and has an area of approximately 60 acres. Woods Pond has several active feed channels in the headwater area. A main channel is in the process of forming an oxbow to the southeast. With the exception of the channels and one deep hole (~16 feet deep), the water is extremely shallow, ranging in depth from 1 to 3 feet. The deep hole is in the southeast section of the lake and covers an area of ~360,000 ft^2. Sediment deposition in this area ranges up to 6 feet. Because there are no channels either into or out of the deep water area, and because there are a number of rock quarries in the immediate area, one possible explanation for its existence is that it may have been a quarry before the area was impounded.

Sediment depths in Woods Pond range from six inches up to ten feet with an average depth of 100 cm (~3 feet). The sediments, for the most part, are composed of a mixture of black, oily organic material with fine sand and silt. In many areas the sediment is layered with humus (peat) materials resembling fine roots. All shallow water areas are heavily laden with aquatic plants, and outgassing is prevalent in much of the pond during the summer months. The water-sediment interface in the more quiescent areas of the pond is layered with a brownish fluffy material. A sample of this material was collected and evaluated as to particle size distribution and PCB content in an investigation relating to sediment transport (Section 4.2.4.2.)

The primary areas of sediment deposition are located along the sides of channels in the headwaters and in the more quiescent areas of the pond. There is very little sediment deposition in the main channel, which is hard cobble overlain with gravel and sand with very little of the black organic material present. Data summaries for Woods Pond proper and the by-pass and holding pond are contained in Table 3-7. The mean concentration of PCB in Woods Pond proper is 24 ppm. The top foot of sediment contains 80% of the PCBs. The calculated load of PCBs in Woods Pond is 7,240 pounds. The constricted channel area (station S18N, Figure 3-8) which extends from the abutment at the end of Housatonic Street to Woods Pond Dam itself (~0.1 mile) is also essentially free of the black organic sediment described previously. The channel bottom consists of boulders, hard cobble, and gravel. It is significant to note that there is no build-up of sediment immediately behind the Woods Pond Dam structure.

There are two apparent reasons for the lack of sediment deposition in Station S18N. The first is the presence of a restraining underwater structure at the head of station S18N. Sonar bottom scans detected the structure, which is approximately 6 feet high and reaches across most of the channel in the area between the former bridge abutments. An area of sediment build-up is behind this structure. The sediment is mostly organic, thinly deposited over sand, gravel and clay.

The second probable reason for the lack of sediment deposition in the channel of Station S18N and behind the dam itself relates to the presence of a by-pass channel around Woods Pond Dam (Figure 3-8). The by-pass channel, which leads to a holding pond (Station S18S) located downstream of Woods Pond, has an intermediary release gate system which discharges into the Housatonic River below Woods Pond Dam. At the southwest and southeast ends of the holding pond, there is an industrial plant inlet and a surface stream discharge which flow

Table 3-7. STATION 18 WOODS POND SEDIMENT DATA

Site No.	Sediment Depth (cm)	Total PCB (ppm)	% of Total (0-32cm)
S18A1	56	100.	81.
S18A2	16	62.	100.
S18B1	112	25.	97.
S18B2	64	14.	100.
S18B3	144	0.44	31.
S18C1	150	1.6	6.
S18C2	112	1.7	70.
S18D1	256	10.	65.
S18D2	80	8.	98.
S18D3	79	1.2	61.
S18E1	64	1.4	85.
S18E2	96	1.5	90.
S18E3	192	1.5	63.
S18F1	184	48.	52.
S18F2	64	6.4	92.
S18F3	76	5.2	89.
S18G1	48	0.11	48.
S18G2	170	83.	22.
S18H1	63	38.	100.
S18H2	207	4.2	72.
S18H3	304	22.	66.
S18I1	208	27.	92.
S18I2	176	33.	76.
S18I3	64	72.	98.
S18J1	64	4.3	94.
S18J2	80	52.	68.
S18K1	62	45.	97.
S18K2	40	0.08	95.
S18K3	79	20.	98.
S18L1	30	17.	100.
S18L2	40	4.4	88.
S18M1	126	5.6	98.
S18M2	45	24.	99.
S18M3	76	48.	97.
S18N	46	0.78	77.
S18P1	10	2.1	100.
S18P2	36	100.	86.
S18P3	5	7.4	100.
S18S1	46	10.	100.
S18S2	80	43.	99.
S18S3	38	33.	98.
S18S4	112	34.	98.
S18S5	40	3.5	100.
S18S6	120	2.6	91.
S18S7	32	74.	100.

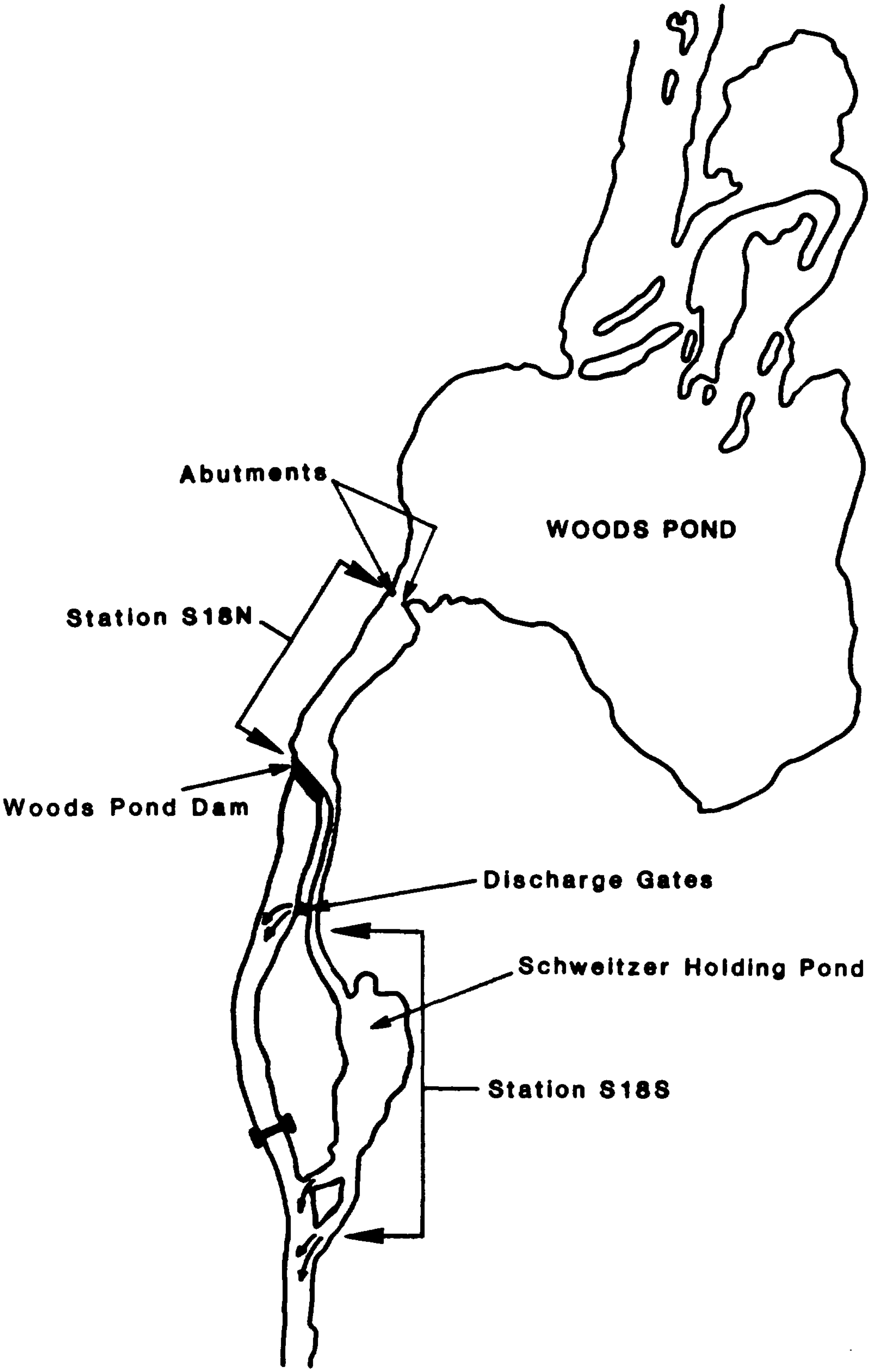


Figure 3-8
Woods Pond, By-Pass, and Schweitzer Holding Pond

back into the river southwest of the holding pond. The by-pass channel is void of deposits and consists of boulders, cobble, gravel, and coarse sand between Woods Pond and the by-pass gate. Sediment deposition gradually begins below the by-pass and increases toward the holding pond, which contains sediment deposits up to 3.5 feet deep. The PCB load of the holding pond is 160 pounds. These observations seem to indicate that the flow of water through the by-pass channel is sufficient to move sediment from the river channel in Station S18N and from behind Woods Pond Dam into the by-pass and out through the intermediary release gate into the Housatonic River downstream of Woods Pond.

Discharge of water from Woods Pond through the by-pass and out the gates into the river is controlled by the P. J. Schweitzer Company. The effect of gate operations on river discharge downstream of the by-pass exit was measured during two of the transport studies. The possible role of the by-pass in sediment transport out of Woods Pond is discussed in Section 4.3.5.

3.3.5 Stations S19-S29.

This station covers 19.4 miles and extends from Woods Pond Dam to Rising Pond Dam. River elevation drops ~230 feet, with an average channel gradient of 12 feet per mile. Both free flowing river and small impoundments are found in this region of river. There are five dams in this stretch of river; however, for the most part, sediment deposition has occurred only in the impoundments of Stations S19, S20, S25, and S27-29. The total PCB load for this river unit is 3300 pounds. The average PCB concentration in the bottom sediments is 3.1 ppm. A summary of PCB distribution for Stations S19-29 is given in Table 3-8.

Table 3-8. PCB DISTRIBUTION S19 - S29

Station No.	Total PCB Conc. (ppm)	Total PCB (pounds)	Structure Locations
19	5.4	174.	Dam at Lenoxdale
20	5.9	320.	Columbia Mill Dam
21	1.4	41.	2 breached dams at Lee
22	1.5	16.	No dams
23	1.1	33.	No dams
24	0.35	5.7	No dams
25	3.1	136.	Willow St. South Lee Dam
26	0.21	6.5	No dams
27	4.9	1230.	Dam at Glendale
28	5.8	155.	2 breached dams near Housatonic
29	4.7	1180.	Rising Pond dam

3.3.6 Stations S30-S36.

This last study unit is 23.9 miles long. Throughout this section the river is characterized by meanders surrounded by oxbows, oxbow lakes, sloughs, splay, and vertical accretion deposits. Sorting of sand and silt is pronounced. Three major tributaries enter the Housatonic River between stations S30 and S34. These are Williams River, Green River, and Hubbard Brook. The average PCB concentration for the area is 0.66 ppm, and the total PCB load for the 24 mile reach is 660 pounds. A data summary for this river unit is contained in Table 3-9.

Table 3-9. PCB DISTRIBUTION STATIONS S30 - S36

Station No.	Average PCB Conc.(ppm)	Total PCB (pounds)
30	1.6	50
31	0.80	85
32	0.14	16
33	0.22	46
34	0.95	277
35	0.25	57
36	0.64	129

3.4 Summary and Conclusions

3.4.1 Summary.

The Houstonic River sediment investigation has determined the extent and quantity of PCB contamination in bottom sediments from Dalton, Massachusetts to the Connecticut state line. A summary of bottom sediment PCB loads is found in Table 3-10.

Based on this survey, the estimated quantity of PCB in the Housatonic River in Massachusetts is 39,400 pounds. Ninety percent of this amount occurs in the

12.5 mile region of the river between the GE plant and Woods Pond Dam. When one considers that PCBs were used at the GE plant for 40 years, this represents an average migration of less than 0.3 mile/year. The major repository for PCB is the 5.3 mile stretch of river and backwaters from New Lenox Road bridge to the headwaters of Woods Pond (station 17) and Woods Pond itself (station 18). Approximately 68% of the PCBs in the Housatonic River are located in these two stations.

Two reaches of the river, upstream of the GE plant and from Rising Pond dam to the Connecticut state line, have an average PCB concentration of <1 ppm. These two sections, which represent 30.23 river miles or 48.6% of the study area, contain less than 2% of the PCBs found in the Housatonic River in Massachusetts.

The balance of the PCBs in the river (~8%) are located in the area between Woods Pond Dam and Rising Pond Dam, a 19 mile reach. In this region, the majority of the PCBs are contained in the reservoirs behind the Monument Mills Dam at Glendale and Rising Pond Dam.

Table 3-10. ESTIMATED QUANTITY OF PCBs IN HOUSATONIC RIVER

Location	PCBs (pounds)	% of Load	Length of river miles
Station S1-8	14	<0.1	6.33
Station S9-12,14,15	3,770	9.6	3.72
Station S16	4,740	12.0	4.09
Station S17 (Backwater 13,000) (River 6,500)	19,500	49.5	4.40
Woods Pond,S18	7,240	18.4	0.38
Woods Pond By-Pass and Holding Pond, S18S	160	0.4	-
Station S19-29	3,300	8.4	19.36
Staion S30-36	660	1.7	23.90
	39,400	100.	62.18

3.4.2 Conclusions. Based on the results of this investigation, the following conclusions are drawn:

(1) PCBs are present in the bottom sediments of the Housatonic River in Massachusetts.

(2) There is no apparent correlation between sediment particle size and PCB concentration in the 12.5 mile reach between the GE outfall and Woods Pond Dam.

(3) The decrease in concentration of PCBs in the top two inches of sediment appears to indicate a covering over of contaminated sediment in certain areas of river backwater and Woods Pond.

(4) The wetland floodplain above Woods Pond and Woods Pond itself with its profuse plant growth have served as traps to limit migration of PCBs downstream of Woods Pond Dam.

(5) The dilution effect due to the influx of uncontaminated sediment is very much apparent in the river downstream of Woods Pond Dam.

SECTION FOUR

SUSPENDED SOLIDS AND PCB TRANSPORT STUDY

4.1 General

The presence and distribution of polychlorinated biphenyls in sediment deposits of the Housatonic River in Massachusetts have been discussed in Section Three of this report. This phase of the project was designed to determine (1) the mechanism(s) by which PCBs are transported and (2) to evaluate the rate of PCB transport from Woods Pond downstream to the Connecticut state line.

An in-depth evaluation of 33 potential transport study sites was conducted during the summer of 1980 (Appendix 2-4). Three key locations were subsequently selected:

(1) Schweitzer bridge at Lenoxdale

(2) Division Street bridge near Great Barrington

(3) Andrus Road bridge

The Schweitzer bridge location is just downstream from Woods Pond, the first impoundment below Pittsfield, Massachusetts. This location represents an inflow site and provides a direct measure of PCB discharge from Woods Pond.

The Division Street bridge near Great Barrington is the site of a USGS gaging station. Historical data covering stream-discharge measurements, gage heights, and suspended-sediment concentrations are available for the site. An outside staff gage is accessible for reading by field personnel. The Andrus Road bridge was selected because of its proximity to the Massachusetts-Connecticut state line. This location serves as an outflow site for the segment of the Housatonic River under investigation. (All three locations are shown on the following map, Figure 4-1).

Three short-term transport investigations were conducted in the first quarter of 1982. The initial study, lasting four days, was conducted in February during a period of typical winter background streamflow conditions. The second short-term study occurred at higher streamflow rates during a snow-melt period in March. The final study in April was conducted during a high-flow period, at which time the river discharge was approximately equal to the mean annual high flow.

4.2 Sampling Program Description

The most widely held assumption relative to PCB transport in the Housatonic River is that deposition, resuspension and redeposition of fine-grained particles containing sorbed PCB is responsible for the transport and distribution of PCBs in the bottom sediments of the river downstream from Pittsfield, Massachusetts. Consequently, the program design included those elements commonly associated with classical USGS sediment transport studies; but provision was also made for the detection of PCB transport modes other than sediment movement, should they exist. Study elements included the following:

(1) Collection of suspended-sediment data,

(2) Determination of PCB content in the suspended-sediment,

(3) Determination of PCB concentration (filterable and nonfilterable) in the water column during each study event, and

(4) Collection of streamflow data characteristics for the short-term events.

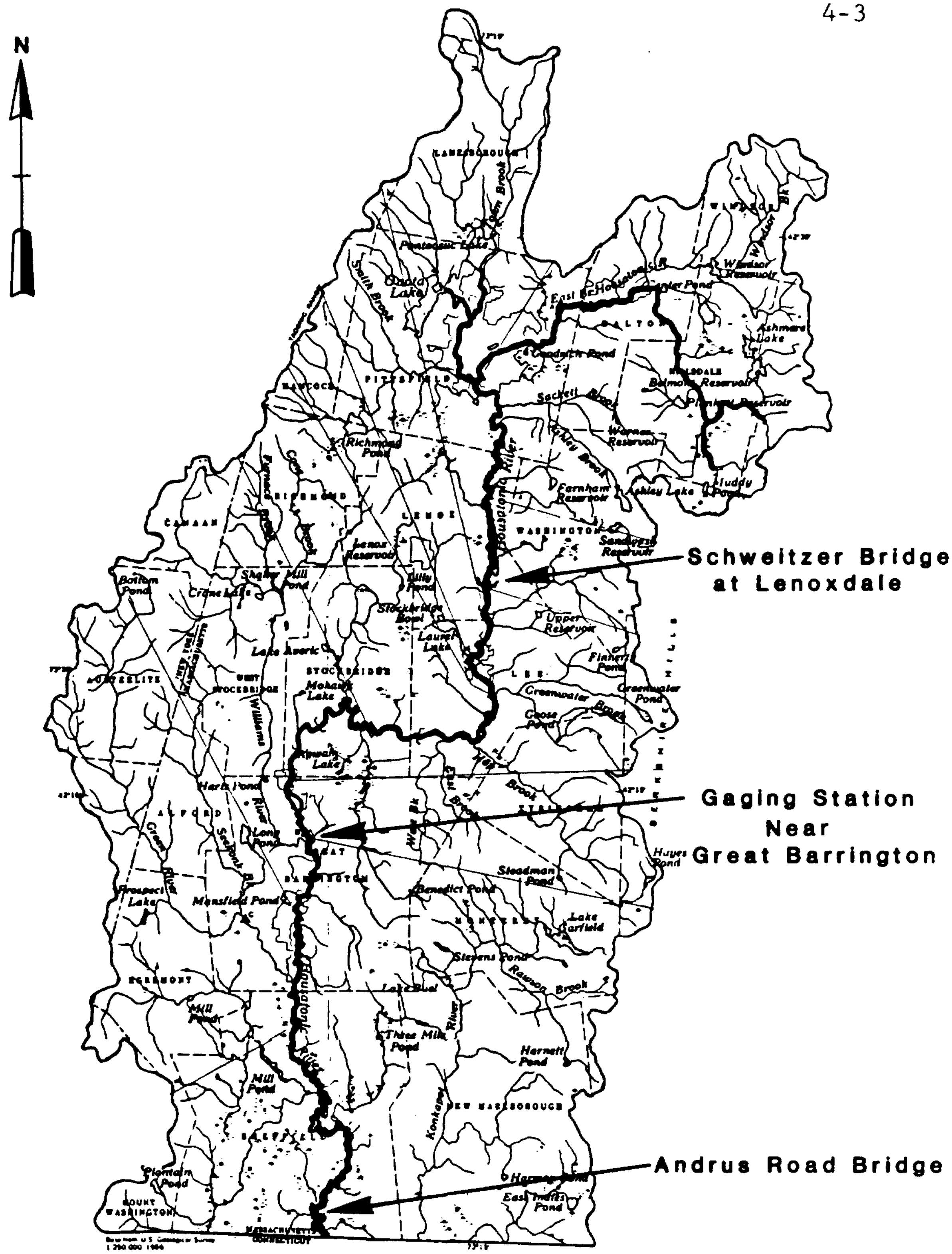


Figure 4-1

Transport Sampling Stations--Housatonic River

4.2.1. Sampling Strategy.

Basically, suspended-sediment discharge at any point is the product of velocity and concentration. To determine the concentration, cross-sectional distribution, and characteristics of the suspended sediment in the river, samples of water-sediment mixture are collected and analyzed in the laboratory. The corresponding water velocity and discharge are obtained from current-meter measurements taken when the water-sediment sample is collected. The basic consideration in the selection of sampling points is that samples obtained should be representative of the quantity as well as the size distribution of sediment prevailing at the time of sampling.

4.2.2. Collections.

Three vertical stations, each representing the centroid of equal discharge, were determined for each station cross-section (see Section 7 of Appendix 4-3). Sampling for each vertical involved the collection of a depth-integrated sample simultaneously with velocity measurements. Sufficient data was collected for the construction of accurate vertical velocity and sediment distribution curves. Sample collection and field quality control protocols are found in Appendix 4-1.

4.2.3. Analytical Methodology.

The analytical methodology selected and the analysis protocol followed in support of the PCB transport study represent state-of-the-art technology. By carefully selecting the sample sizes used for analysis, the limits of detection for PCBs in suspended sediment have been lowered by a factor of three below the limit of standard USGS methodology. In addition, the use of a special compositing technique resulted in detection limits which were a factor of 10 lower than that of the USGS method.

Samples collected in support of the transport study are analyzed for nonfilterable and filterable PCB concentrations and for suspended-sediment concentrations. The analysis protocol for the determination of suspended sediments is EPA Method 160.2, "Non-filterable Residue." The method specifies a sample volume of 100 ml as standard; however, the method requires that the sample volume be increased for residues less than 4 mg/liter. To assure adherence to this requirement, the analysis protocol specifies that the total sample collected (approximately 900 ml) be filtered. The filtered sample is subsequently analyzed for "filterable" PCB concentration. Suspended solids (non-filterable residue) are determined according to standard procedure. "Insoluble" or non-filterable PCB concentrations are subsequently determined by analyzing the total filter plus suspended solids residue for PCBs. The total PCB concentration of water-sediment mixture is then the sum of the filterable plus non-filterable PCB concentrations. By way of definition, the Whatman 934 AH filter employed has an effective retention of 1.5 microns.

The standard approach for calculating "apparent" PCB concentration of suspended sediment is to divide the total PCB concentration in the sample (expressed as µg/l) by the suspended sediment concentration (mg/l). A comparison of detection limits for "apparent" PCB concentations for selected suspended sediment concentrations is given in Table 4-1. These calculations are based on the published detection limit of 0.1 ppb (100 ppt) for the USGS method and detection limits of 0.03 ppb (30 ppt) and 0.01 ppb (10 ppt) for the Stewart Laboratories methods. A comparison of method details is found in Appendix 4-2.

Table 4-1. COMPARISON OF METHOD DETECTION LIMITS

Suspended Sediment Conc. (Non-filterable solids, ppm)	Level of Detectibility for "Apparent" PCB Conc. of Suspended Sediment, ppm		
	USGS	SLI	Special SLI
1.0	100	30	10
5.0	20	6	2
10.0	10	3	1
50.0	2	0.6	-
100.0	1	0.3	-
200.0	0.5	-	-

4.2.4 Special Particle Size Distribution Studies.

The PCB/sediment transport collection protocol included a provision for determining a particle size distribution profile for each station cross-section provided sediment loads were appropriate for accurate weight measurements. This collection criteria could not be met at Schweitzer or Great Barrington because of low suspended solids load. An adequate sample was collected, however, at the Andrus Road site. In addition, a special suspended sediment sample was collected in Woods Pond to provide some insight into the particle size distribution present in sediments at the water-sediment interface.

4.2.4.1 Particle Size Distribution-Andrus Road Site Suspended Sediment. A special sample was collected at the Andrus Road site during the March 1982 snow melt event. The sample was composed of a one-half gallon depth-integrated sample from the center of each of twenty-five 5-foot sections of the bridge. The samples were allowed to settle and remained undisturbed for a period of two weeks before the supernate was removed and the sediment from the 25 individual samples was composited into a single suspended-solids aliquot. Particle size distribution for the sample, which weighed 1.77 grams, involved both screening and a standard pipette test. Results are given in Tables 4-2 and 4-3, respectively.

Table 4-2. Particle Size Distribution for Suspended Sediment-Andrus Road

Screen Size (mesh)	Nominal Particle Size (microns)	Percent	PCB Conc. (µg/g, ppm)
1.0	>1000	0.	-
0.5	1000-500	0.	-
60.	500-250	0.	-
140.	250-100	5.08	6.3
300.	100-50	5.08	0.54
-300.	<50	89.27	0.60

The weighted average concentration of PCB for the suspended sediment composite is

$$\frac{\Sigma(5.08\% \times 6.3) + (5.08\% \times 0.54) + (89.27\% \times 0.60)}{100\%} = 0.88 \text{ ppm}$$

This value compares most favorably with the average PCB value of 0.9 ppm determined for the three centroids of flow composites collected during the same day of this event (See Table 4-16).

These data do not necessarily indicate that PCB are preferentially associated with the larger particle sizes. It more probably indicates that the majority of the sediment in the silt-clay fraction entered from locations not associated with the PCB source and represent "clean" sediment.

The -300 mesh fraction (<50 microns) of the sample was then subjected to further particle size evaluation by the standard pipette test technique.

Table 4-3. Pipette Test Results - Andrus Road Suspended Sediment

Size Range (microns)	Description	Percent of -300 mesh fraction
<50 but >20	Coarse Silt	40.9
<20 but >5	Medium & Fine Silt	25.6
<5 but >2	Coarse Clay	23.3
<2	Medium & Fine Clay	10.2

SIGNIFICANT OBSERVATIONS

(1) The particle size distribution for the suspended sediment sample is consistent with the silt and clay ($<62\mu$) size distributions which one would expect to find held in suspension by the velocity of the stream under these flow conditions.

(2) The silt and clay fractions (~95%) of the suspended sediment sample show only minimal levels of PCBs present. This indicates that the predominate source of the silt-clay fraction at Andrus Road bridge is run-off from the drainage basin downstream of Woods Pond.

4.2.4.2 Particle Size Distribution - Special Woods Pond Sediment. A special experiment was conducted in sediment Stations 18 (Woods Pond) and 17 (oxbow area upstream of Woods Pond) to determine the "silting-over" effect in these two areas known to contain sediments with high PCB concentrations. Full details of this study can be found in Section 3.2.3.

As a part of this study, the sediment-water interface in Woods Pond was examined using a cryogenic sampling probe. This examination revealed the presence of a fluffy, brownish material in the top 0-2 inches of the bottom sediment of the pond. Since this material appears to be a prime candidate for resuspension and transport of PCB associated with bottom sediments in the Housatonic River, a special experiment was conducted to characterize the water-sediment interface relative to particle size distribution and PCB content. A boat was carefully of Woods Pond. Water depth at this location was ~2.5 feet. A cleaned paddle was used to create turbulence in the water, but care was taken to insure that the paddle did not actually touch the bottom. Suspension of sediment was due only to water movement. Significant sediment suspension resulted, yielding an artificial "worst-case" storm event. Twelve quarts of water-suspended sediment mixture were collected during this experiment. Eight of the samples were combined to produce a suspended sediment composite in the same manner as that used with the Andrus Road suspended sediment composite. Both a conventional sieve analysis and pipette test were used for particle size distribution analysis.

Two additional samples were carefully homogenized and then split for treatment as duplicate samples. One split was filtered using the standard glass fiber filter used for the transport study with an effective retention of 1.5 microns. The second split was filtered through a glass-fiber filter with an effective retention of 0.3 microns. Both samples were analyzed for filterable and non-filterable PCB content.

Particle size distribution data are given in Table 4-4, pipette test results are found in Table 4-5, and the special split sample PCB analyses are tabulated in Table 4-6.

Table 4-4. Particle Size Distribution for Suspended Sediment from Special Woods Pond Experiment

Screen Size (Mesh)	Nominal Particle Size (microns)	Percent	PCB Conc. (μg/g, ppm)
1.	>1000	0	
0.5	1000 - 500	0	
60.	500 - 250	0	
140.	250 - 100	24.84	55.
300.	100 - 50	27.30	44.
-300.	<50	47.30	34.

Table 4-5. Pipette Test Results - Woods Pond

Size Range (Mesh)	Description	Percent of -300 Mesh Fraction
<50 but >20	Coarse silt	53.4
<20 but >5	Medium and fine silt	37.4
<5 but >2	Coarse clay	6.5
<2	Medium and fine clay	2.9

Table 4-6. Special Woods Pond Suspended Sediment

Sample	PCB Conc. in Non-Filterable Solids (ppm)	Filterable PCB in Sed./H_2O Mixture (ppb)
Sed./H_2O filtered through 1.5 micron filter	32.	0.07
Sed./H_2O filtered through 0.3 micron filter	29.	0.07

SIGNIFICANT OBSERVATIONS

(1) It should be noted that the particle size distribution of the special Woods Pond suspended sediment sample is composed primarily of fine sands and coarse silt, while the Andrus Road suspended sediment is primarily silt and clay. The particle size distribution exhibited by the Woods Pond suspended sediment is consistent with the geological make-up of the drainage area of the region. The particle size distribution for the Andrus Road suspended sediment is likewise consistent with the geology of that drainage area.

(2) Another pertinent observation relates to the presence of filterable PCBs in the filterable fraction (both <1.5 and <0.3 micron) of the sediment/water mixture. This value, 70 ppt, can be related to the filterable PCB concentration of 70 to 80 ppt observed at the Schweitzer bridge for discharge levels above 2100 ft^3/sec observed during the April 1982 storm event.

(3) The PCB concentration of ~30 ppm for the suspended solids contained in the water-sediment mixture probably represents a realistic estimate for a PCB-laden suspended sediment with no benefit of

dilution with "clean" sediment from basin runoff. The maximum PCB concentration observed in suspended sediment at Schweitzer bridge, 21 ppm, occurred during the April 1982 storm event. Based on these data, it would appear that approximately two-thirds of the suspended sediment load at Schweitzer during the April 1982 storm event was due to resuspension of PCB laden sediment from the river, and approximately one-third of the load resulted from storm runoff into the river.

4.3 Short-term Event Descriptions and Experimental Data

The Consent Order of May 26, 1981 requires that a program shall attempt to determine existing and potential patterns of disposal of PCBs from bottom sediments into the waters of the Housatonic River. In keeping with this requirement, three short-term intense research investigations were conducted in the first quarter of 1982 for purposes of evaluating the mechanism of transport of PCBs in the Housatonic River. The initial study, lasting four days, was conducted during a period of typical winter background flow conditions. The second was a short-term event occurring during a snow-melt period in March. The high flow event of the season, corresponding to the mean annual flood (2.3 year event) was the third event used for transport evaluation purposes.

Event descriptions and pertinent related experimental data are presented individually. Section 4.3.4 contains data summaries for each of the three transport sites. The final section (4.3.5) describes findings relating to the Woods Pond Dam by-pass channel.

4.3.1 Winter (February 1982) Background Study.

Initial discharge measurements were made at the Great Barrington and Andrus Road sites during this study period. However, the majority of the effort was concentrated on an evaluation of the Schweitzer Bridge site and the Woods Pond Dam by-pass channel.

A total of 68 water-sediment mixture samples from this initial four day study were analyzed for total nonfilterable solids, PCB content of nonfilterable solids, and filterable PCB content. The filterable PCB content of all samples was below detection (<0.03 ppb). The PCB concentration in the majority (90%) of the nonfilterable solids was also below detection. It was observed, however, that when positive PCB data were obtained, they were associated primarily with those samples which contained discrete suspended materials. A summary of these results is found in Table 4-7.

Table 4-7. Suspended Solids Yielding Positive PCB Results

Sample No.	Description	Nonfilterable PCB in Water-Sediment Sample (ppb)	Nonfilterable Suspended Solids (ppm)	PCB in Suspended Solids (ppm)
X-2727	Sta 12, Greenish Residue	0.04	2.4	17.
X-2729	Sta 12, Brown Fluffy	0.14	10.8	13.
X-2734	Sta 4, Clump Algae	0.09	8.1	11.
X-2736	Sta 6, Greenish Residue	0.04	3.1	13.
X-2737	Sta 7, Piece Plant	0.07	3.5	20.
X-2740	Sta 9, Greenish Residue	0.04	2.2	18.
X-2744	Sta 5-6, Greenish Residue	0.03	2.0	15.
	Average:	0.064	4.6	15.

Two studies were conducted at the Schweitzer Bridge site to determine the uniformity of the suspended solids in the water column. The first involved sampling of the individual sections which comprised the first centroid of flow (Table 4-8).

Table 4-8. Special Uniformity Study - Discharge = 405 ft^3/sec

Sample No.	Location	Nonfilterable PCB in Water-Sediment Sample (ppb)	Nonfilterable Suspended Solids (ppm)	PCB in Suspended Solids (ppm)
X-2733	Sta 3	<0.03	3.7	<8.
X-2734	Sta 4	0.09	8.1	11.
X-2735	Sta 5	<0.03	3.5	<9.
X-2736	Sta 6	0.04	3.1	13.
X-2737	Sta 7	0.07	3.5	20.
X-2739	Sta 8	<0.03	2.6	<12.
X-2740	Sta 9	0.04	2.2	18.
		Average:	3.8	

The second study involved replicate sampling at one flow-centroid sampling location. The data are contained in Table 4-9.

Table 4-9. Replicate Depth-Integrated Sampling - Discharge = 405 ft^3/sec

Sample No.	Location	Nonfilterable PCB in Water-Sediment Sample (ppb)	Nonfilterable Suspended Solids (ppm)	PCB in Suspended Solids (ppm)
X-2727	Sta 12	0.04	2.4	17.
X-2728	Sta 12	<0.03	2.8	<11.
X-2729	Sta 12	0.14	10.8	13.
X-2730	Sta 12	<0.03	1.6	<19.
X-2731	Sta 12	<0.03	2.2	<14.
X-2732	Sta 12	<0.03	4.0	<8.
		Average:	4.0	

Results from these two studies show that for an average nonfilterable residue concentration of 3.9 ppm, the concentration of PCB in the nonfilterable residue ranges from <8. to 20. ppm. These studies lead to the conclusion that during ambient winter flow, the nonfilterable solids are not uniformly distributed in the sediment-water mixture. The data also show that the PCB concentration of the nonfilterable solids exhibits a high degree of variability.

By regulating the gates on the Schweitzer by-pass canal, it was possible to vary the discharge at the Schweitzer bridge between 234 and 405 ft^3/sec. Studies were conducted at two ambient river flow conditions (gates closed) and one "high-flow" (gates open) condition. Data obtained for these conditions are tabulated in Table 4-10. These results indicate that the nonfilterable residue concentration of the sediment-water mixture increases with increased flow.

During this period of ambient winter background flow conditions, the PCB concentration of the water-sediment mixture at all three transport sites was less than thirty parts per trillion for both the filterable (<1.5 micron) and nonfilterable (>1.5 micron) fractions of the sample. A summary of instantaneous discharge comparisons for ambient winter transport is found in Table 4-11.

4.3.2 Snow Melt (March 1982).

During this event, a special compository technique was used for analyzing the nonfilterable solids residues for PCB content. Filters for each centroid of flow were combined for analysis, thereby lowering the limit of detection to 10 ppt. The only apparent transport made during this snow melt event was suspended PCB transport associated with the nonfilterable suspended solids. This mechanism was observed at the Schweitzer and Andrus Road locations. During the period of this investigation, the PCB concentration of the water-sediment mixture at all three stations was <30 ppt for the filterable (<1.5 micron) fraction. The PCB concentration of the nonfilterable (>1.5 micron) portion was

Table 4-10. Schweitzer Bridge - Winter Background Study

Date	Instantaneous Discharge ft^3/sec	Nonfilterable Suspended Solids (ppm)	Suspended Solids Discharge (tons/day)	Nonfilterable PCB in Water-Sediment Sample (ppb)	PCB in Suspended Solids (ppm)	Filterable PCB in Water-Sediment Sample (ppb)	Estimated PCB Transported (lbs/day)(gm/day)
2/24/82	234	1.0	0.63	B.D.[1]	B.D.[2] (<30)	B.D.[1]	None Detected
2/24/82	405*	3.8	4.16	0.03	8.	B.D.[1]	0.067 30.
2/24/82	273	1.4	1.03	B.D.[1]	B.D.[2] (<21)	B.D.[1]	None Detected

*Gates wide open

B.D.[1] = Below Detection. The detection limit for PCB in the water-sediment samples is 0.03 parts per billion.

B.D.[2] = Below Detection. The detection limit for PCB in the suspended solids (nonfilterable residue) samples varies as a function of the total residue present.

Table 4-11. Typical Ambient Winter Transport

Location	Instantaneous Discharge ft^3/sec	Nonfilterable Suspended Solids (ppm)	Suspended Solids Discharge (tons/day)	Total PCB in Water-Sediment Sample (ppb)	Estimated PCB Transported (lbs/day)(gm/day)
Schweitzer	<300	2.0	1.6	B.D.*	None Detected
Great Barrington	<500	3.0	4.1	B.D.	None Detected
Andrus Road	<750	7.5	15.2	B.D.	None Detected

*B.D. = Below Detection. The detection limit for PCB in the water-sediment sample is 0.03 parts per billion.

30 ppt for Schweitzer, >30 ppt for Great Barrington, and 50 ppt for Andrus Road. A summary based on instantaneous discharge computations for this snow melt event is found in Table 4-12.

The Andrus bridge site was studied extensively during this event. Each of the three centroids of flow were verified relative to discharge measurements and nonfilterable solids determinations for each 5-foot station (See Tables 4-13 to 4-15). A special composite of filters for each centroid was analyzed for PCB. This approach gave sufficient sensitivity to confirm the presence of Aroclor 1242 in the nonfilterable residue at a concentration of 3 ppt. A summary of PCB data is found in Table 4-16.

At the conclusion of the March event, a second investigation was conducted involving regulation of the gates on the Schweitzer by-pass canal. The river discharge increased to 550 ft^3/sec accompanied by an increase in both suspended solids and PCB load. The amount of PCB being transported increased almost four-fold over the "gates closed" discharge condition. A comparison of the "gates-open" conditions with data for the "gates-closed" snow melt study is contained in Table 4-17.

Table 4-12. Snow Melt Transport Summary

Location	Mean Instantaneous Discharge ft^3/sec	Average Nonfilterable Suspended Solids (ppm)	Average Suspended Solids Discharge (tons/day)	Average PCB in Suspended Solids (ppm)	Average Total PCB in Water-Sediment Sample (ppb)	PCB Transport (lbs/day)	PCB Transport (g/day)
Schweitzer	414	7.5	8.38	4.2	0.03	0.068	31.
Great Barrington	871	5.5	12.9	B.D.[1](<2)*	B.D.[2]*	None Detected	
Andrus Road	1425	44.1	170.	0.9	0.05	0.35	160.

*B.D.[1] = Below Detection. The detection limit for PCB in the suspended solids (nonfilterable residue) samples varies as a function of the total residue present.

B.D.[2] = Below Detection. The detection limit for PCB in the water-sediment sample is 0.01 parts per billion for this event.

Table 4-13. Uniformity Study-Centroid One (47') - Andrus Bridge

Sample No.	Description	Nonfilterable Solids (ppm)
X-7251	Sta 20'	46.3
X-7252	Sta 25'	46.6
X-7253	Sta 30'	52.8
X-7254	Sta 35'	44.3
X-7255	Sta 40'	50.6
X-7256	Sta 45'	49.6
X-7257	Sta 50'	52.4
X-7258	Sta 55'	54.4
X-7259	Sta 60'	54.2
	Average:	50.1

Table 4-14. Uniformity Study-Centroid Two (65') - Andrus Bridge

Sample No.	Description	Nonfilterable Solids (ppm)
X-7260	Sta 65'	54.0
X-7261	Sta 70'	31.8
X-7262	Sta 75'	50.2
X-7263	Sta 80'	49.0
X-7264	Sta 85'	48.1
X-7265	Sta 90'	51.7
X-7266	Sta 95'	50.8
	Average:	47.9

Table 4-15. Uniformity Study-Centroid Three (115') - Andrus Bridge

Sample No.	Description	Nonfilterable Solids (ppm)
X-7267	Sta 100'	59.2
X-7268	Sta 105'	59.2
X-7269	Sta 110'	57.1
X-7270	Sta 115'	56.9
X-7271	Sta 120'	58.1
X-7272	Sta 125'	48.9
X-7273	Sta 130'	62.9
X-7274	Sta 135'	65.0
X-7275	Sta 140'	96.9
	Average:	62.7

Table 4-16. PCB Analysis - Andrus Road Bridge Centroids

Sample Description	Instantaneous Discharge ft^3/sec	Nonfilterable Suspended Solids (ppm)	PCB in Suspended Solids (ppm)	Nonfilterable PCB in Water-Sediment Sample (ppb) Aroclor 1242	Aroclor 1254	Aroclor 1260	Total PCB
Centroid One Composite	1250	50.1	0.9	0.003	0.015	0.029	0.047
Centroid Two Composite	1250	47.9	1.0	0.003	0.018	0.025	0.046
Centroid Three Composite	1360	62.7	0.7	0.003	0.018	0.021	0.042
Average:	1287	53.6	0.9	0.003	0.017	0.025	0.045

Table 4-17. Schweitzer Bridge - March Snow Melt

Date	Instantaneous Discharge ft^3/sec	Nonfilterable Suspended Solids (ppm)	Suspended Solids Discharge (tons/day)	Nonfilterable PCB in Water-Sediment Sample (ppb)	PCB in Suspended Solids (ppm)	Filterable PCB in Water-Sediment Sample (ppb)	Estimated PCB Transported (lbs/day)	(gm/day)
3/13/82	358	8.2	7.93	0.033	4.	B.D.	0.063	29.
3/14/82	427	9.0	10.4	0.032	4.	B.D.	0.083	38.
3/15/82 am	457	6.4	7.90	0.028	4.	B.D.	0.063	29.
3/15/82 pm	457	4.4	5.43	0.022	5.	B.D.	0.054	25.
3/16/82	550*	8.6	12.8	0.070	8.*	B.D.	0.204	92.

B.D. = Below Detection. The detection limit for PCB in the water-sediment sample is 0.03 parts per billion.

* Gates wide open.

4.3.3 Storm Event (April 1982).

A five-day storm event, corresponding in magnitude to a mean annual flood (2.3 year event), was studied in April 1982. It is significant to note that during this investigation, PCBs were detected in the filterable (<1.5 micron) fraction of the water-sediment mixture at all three sites. In addition, positive PCB concentrations were found in the filterable fraction of water-sediment samples collected at the test bridge located over the Woods Pond by-pass canal.

Although transport as filterable PCBs in the water column has an impact on PCB transport in the Housatonic River, the dominant transport mode for the storm event involved nonfilterable suspended PCBs. Resuspension and transport of PCB-laden sediments from the stream channel were observed at the following flows: Schweitzer, >700 ft^3/sec; Great Barrington, >1100 ft^3/sec; and Andrus Road, >1750 ft^3/sec.

A listing of the more significant observations relating to the storm event follows:

Schweitzer

(1) The PCB concentration of the sediment-water mixture varied from 20 to 80 ppt for the filterable fraction (<1.5 microns) while the concentration of the nonfilterable (>1.5 micron) fraction ranged from 40 to 150 ppt.

(2) PCBs in the filterable fraction are associated with flows greater than 700 ft^3/sec. This fraction accounted for about one-third of the total PCB transported past the Schweitzer bridge during this event.

(3) The PCB content of the nonfilterable suspended solids residue ranged from 6 to 21 ppm.

(4) Based on instantaneous discharge measurements, the total PCB transported past this station during this event was calculated to be approximately 5.2 pounds.

Great Barrington

(1) The PCB concentration of the sediment-water mixture varied from below detection to 40 ppt for the filterable fraction (<1.5 micron) while the concentration of the non-filterable fraction (>1.5 micron) ranged from 30 to 100 ppt.

(2) PCBs in the filterable fraction are associated with flows greater than 1750 ft^3/sec. Filterable PCB concentrations accounted for about one-fourth of the total PCB transported past Great Barrington during this event.

(3) The PCB content of the nonfilterable suspended solids residue ranged from 5.4 to 7.5 ppm.

(4) Based on instantaneous discharge measurements, the total PCB transported past this station during the storm event was approximately 4.4 pounds.

Andrus Road

(1) During this event, the PCB concentration of the sediment-water mixture varied from below detection to 10 ppt for the filterable fraction (<1.5 micron) while the concentration of the non-filterable fraction (>1.5 micron) ranged from 40 to 70 ppt.

(2) PCBs in the filterable fraction are associated with flows greater than 3900 ft^3/sec. This fraction accounted for about 8% of the total PCB transported past this site during this storm event.

(3) The PCB content of the nonfilterable suspended solids residue ranged from 0.5 to 1.1 ppm.

(4) Based on computations related to instantaneous discharge measurements, the total PCB transported past this station during this storm event was approximately 4.6 pounds.

A summary based on instantaneous discharge computations for this storm event is found in Table 4-18. A comparison of total PCB transported by site is represented graphically in Figure 4-2.

Table 4-18. April 1982, Storm Event Transport Summary

Location	Estimated Sediment Load for Event (tons)	Average PCB in Suspended Solids (ppm)	Maximum Instantaneous Discharge (ft^3/sec)	Average Instantaneous Discharge (ft^3/sec)	Estimated PCB Transported for Event (pounds)
Schweitzer	126.	15.	2320	1300	5.2
Gt. Barrington	285.	6.4	2960	1850	4.4
Andrus Road	2600.	0.9	4800	3000	4.6

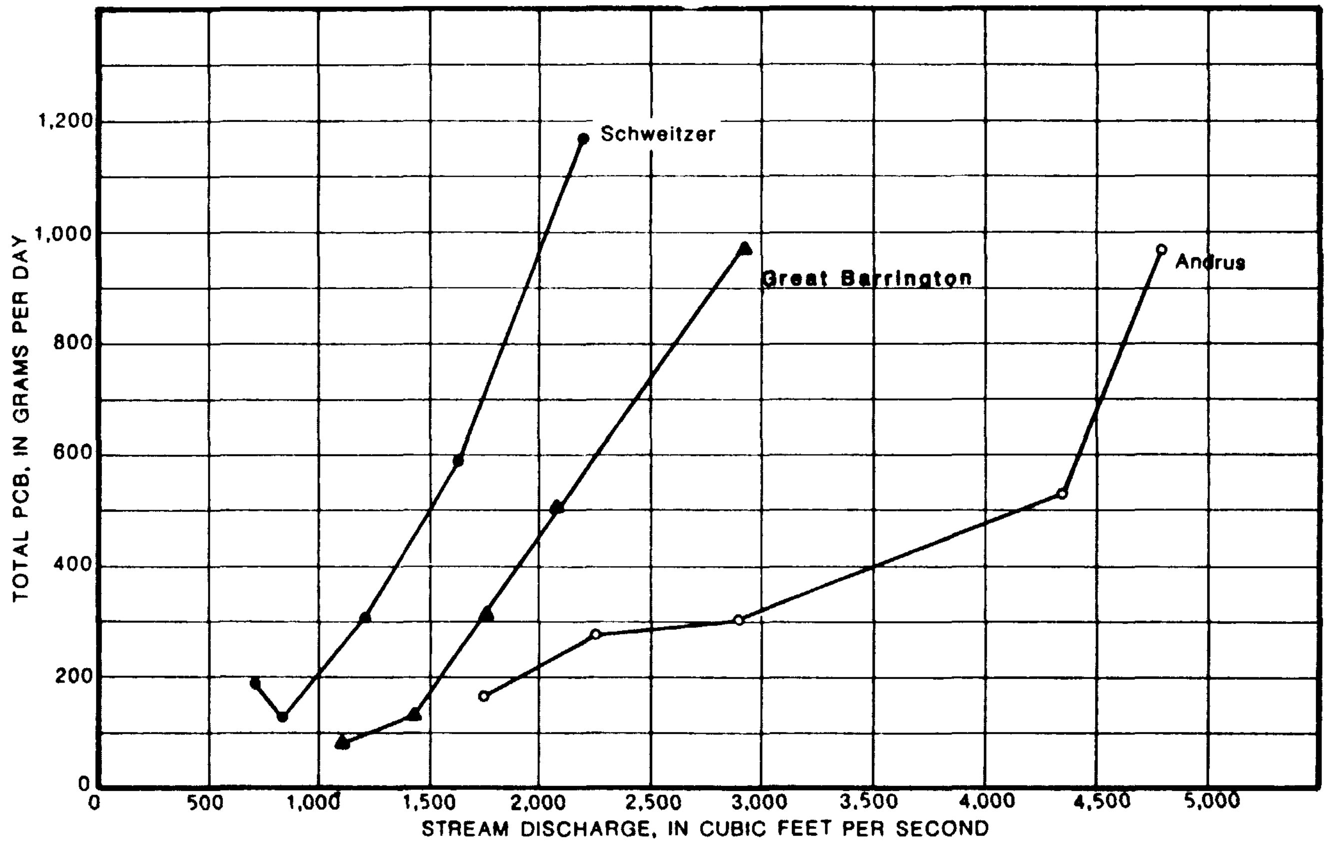


Figure 4-2

Total PCB Transported During April 1982 Storm Event Versus Flow

4.3.4 Transport Data Summaries.

Summaries of transport data are arranged by site as follows: Table 4-19, Schweitzer Bridge; Table 4-20, Great Barrington; and Table 4-21, Andrus Road Bridge.

4.3.5 Woods Pond Dam By-Pass Studies.

As discussed earlier in Sections 4.3.1 and 4.3.2 of this section, regulation of water discharge by opening the gates of the Woods Pond dam by-pass channel caused significant changes in both river flow and PCB transport past the Schweitzer Bridge site (Tables 4-10 and 4-17). A map showing strategic locations relative to this topic is presented as Figure 4-3.

In early February 1982, GE installed a footbridge across the by-pass channel approximately 50 feet downstream of Woods Pond Dam. This location served as a work station for the by-pass channel investigations. A channel profile at the GE footbridge is shown in Figure 4-4. This shows the bottom and cross-sectional area under winter background conditions (2/23/82) with the gates closed. Depending upon the river stage and upon the position of the sluice gates, flow in the by-pass canal may vary from near zero to several hundred cubic feet per second. Field investigations in 1980 have shown that sediment deposition in the channel is negligible.

Transport of PCB from Woods Pond by way of this diversionary by-pass was measured on two occasions -- during the March snow melt and the April storm event. Results are given in Table 4-22.

During the February and March transport studies, SLI personnel were permitted to adjust the sluice gates at their discretion. However, regulation of the gates

Table 4-19. Schweitzer Bridge Site - Transport Data Summary

Date and Time	Instantaneous Discharge (ft^3/Sec)	Nonfilterable Suspended Solids (ppm)	Suspended Solids Discharge (tons/day)	Nonfilterable PCB in Water-Sediment Sample (ppb)	PCB in Suspended Solids (ppm)	Filterable PCB in Water-Sediment Sample (ppb)	Estimated Total PCB Transported (lbs/day)	Estimated Total PCB Transported (gm/day)
February Winter Background								
2/24/82 10:00 a.m.	234	1.0	0.63	B.D.[1]	B.D.[2](<30)	B.D.[1]	None Detected	
2/24/82 2:30 p.m.	405*	3.8	4.16	0.03	8.0*	B.D.[1]	0.067	30.
2/27/82 8:15 a.m.	273	1.4	1.03	B.D.[1]	B.D.[2](<21)	B.D.[1]	None Detected	
March Snow Melt								
3/13/82 11:00 a.m.	358	8.2	7.93	0.033	4.0	B.D.[1]	0.063	29.
3/14/82 10:30 a.m.	427	9.0	10.4	0.032	4.0	B.D.[1]	0.083	38.
3/15/82 11:20 a.m.	457	6.4	7.90	0.028	4.0	B.D.[1]	0.063	29.
3/15/82 6:15 p.m.	457	4.4	5.43	0.022	5.0	B.D.[1]	0.054	25.
3/16/82 5:40 p.m.	550*	8.6	12.8	0.070	8.0*	B.D.[1]	0.20	92.
April Storm Event								
4/20/82 4:00 a.m.	2320	7.5	46.9	0.15	20.	0.08	2.88	1306.
4/20/82 7:00 a.m.	2080	8.9	49.9	0.13	15.	0.07	2.28	1032.
4/20/82 5:00 p.m.	1740	7.8	36.6	0.08	10.	0.05	1.20	545.
4/21/82 12 Noon	1520	5.7	23.4	0.11	19.	0.06	1.38	626.
4/22/82 9:00 a.m.	1310	6.6	23.3	0.08	12.	0.02	0.70	318.
4/22/82 9:00 p.m.	1115	9.4	28.3	0.08	9.	0.02	0.63	285.
4/23/82 10:00 a.m.	830	6.8	15.2	0.04	6.	0.02	0.27	124.
4/24/82 12 Noon	705	3.3	6.3	0.07	21.	0.04	0.42	189.

*By-pass gates open.

B.D.[1] = Below Detection. Unless otherwise noted, the detection for PCB in the water-sediment samples is 0.03 parts per billion.

B.D.[2] = Below Detection. The detection limit for PCB in the nonfilterable suspended-solids samples varies as a function of the total residue present.

Table 4-20. Great Barrington Site - Transport Data Summary

Date and Time	Instantaneous Discharge (ft^3/Sec)	Nonfilterable Suspended Solids (ppm)	Suspended Solids Discharge (tons/day)	Nonfilterable PCB in Water-Sediment Sample (ppb)	PCB in Suspended Solids (ppm)	Filterable PCB in Water-Sediment Sample (ppb)	Estimated Total PCB Transported (lbs/day)	(gm/day)
February Winter Background								
2/27/82 2:45 p.m.	510	2.4	3.30	B.D.[1]	B.D.[2](<13)	B.D.[1]	None Detected	
March Snow Melt								
3/13/82 2:00 p.m.	686	5.2	9.63	B.D.[1]	B.D.[2](<2)	B.D.[1]	None Detected	
3/14/82 12:30 p.m.	952	6.2	15.9	B.D.[1]	B.D.[2](<2)	B.D.[1]	None Detected	
3/15/82 2:15 p.m.	967	5.1	13.3	B.D.[1]	B.D.[2](<2)	B.D.[1]	None Detected	
3/16/82 2:00 p.m.	880	5.5	13.1	B.D.[1]	B.D.[2](<2)	B.D.[1]	None Detected	
April Storm Event								
4/20/82 9:00 a.m.	2,960	19.	149.	0.10	5.4	0.04	2.25	1018.
4/20/82 11:00 a.m.	2,890	17.	130.	0.09	5.4	0.04	2.02	914.
4/21/82 1:00 p.m.	2,094	9.7	54.8	0.06	6.2	0.04	1.13	511.
4/21/82 4:00 p.m.	2,046	11.	58.0	0.07	6.7	0.03	1.10	500.
4/22/82 12:00 Noon	1,760	8.0	38.0	0.05	6.7	0.02	0.70	310.
4/23/82 12:00 Noon	1,460	5.6	22.1	0.04	7.1	B.D.[1]	0.31	141.
4/23/82 3:00 p.m.	1,352	5.3	19.3	0.04	7.5	B.D.[1]	0.29	131.
4/24/82 6:00 p.m.	1,101	5.0	14.9	0.03	6.0	B.D.[1]	0.18	80.

B.D.[1] = Below Detection. Unless otherwise noted, the detection limit for PCB in the water-sediment samples is 0.03 parts per billion.

B.D.[2] = Below Detection. The detection limit for PCB in the nonfilterable suspended-solids samples varies as a function of the total residue present.

Table 4-21. Andrus Road Bridge Site - Transport Data Summary

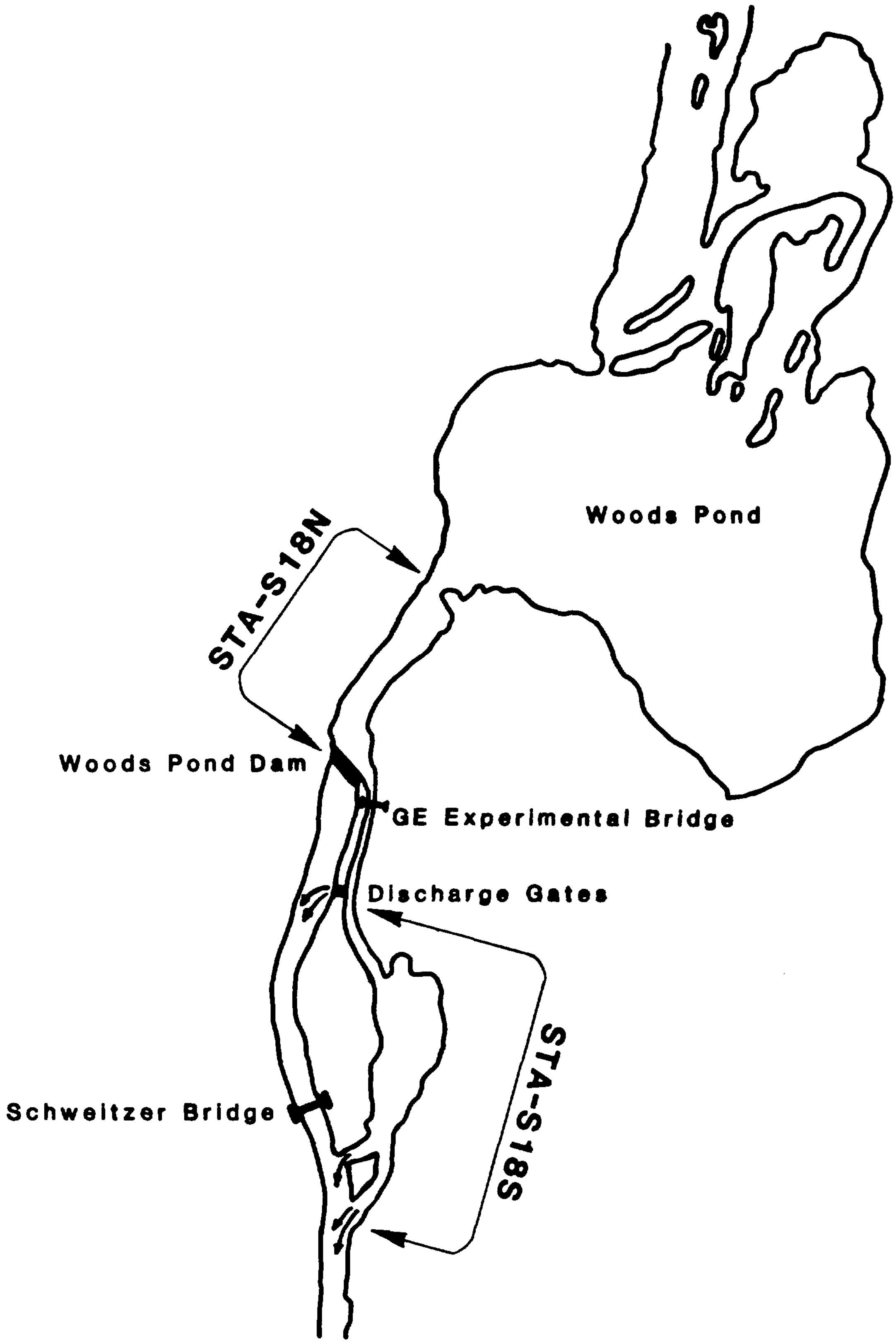
Date and Time	Instantaneous Discharge (ft^3/Sec)	Nonfilterable Suspended Solids (ppm)	Suspended Solids Discharge (tons/day)	Nonfilterable PCB in Water-Sediment Sample (ppb)	PCB in Suspended Solids (ppm)	Filterable PCB in Water-Sediment Sample (ppb)	Estimated Total PCB Transported (lbs/day)	Estimated Total PCB Transported (gm/day)
February Winter Background								
2/27/82 1:10 p.m.	820	7.5	16.6	B.D.[1]	B.D.[2](<4)	B.D.[1]	None Detected	
March Snow Melt								
3/14/82 2:00 p.m.	1320	54.	191.	0.045	0.8	B.D.[1]	0.31	138.
3/15/82 3:30 p.m.	1500	46.	185.	0.048	1.1	B.D.[1]	0.41	184.
3/15/82 4:30 p.m.	1525	44.	180.	0.048	1.0	B.D.[1]	0.36	163.
3/16/82 1:20 p.m.	1440	34.	133.	0.048	1.4	B.D.[1]	0.37	169.
April Storm Event								
4/20/82 11:15 a.m.	4800	90.	1170.	0.07	0.8	0.01	2.13	962.
4/20/82 2:20 p.m.	4800	91.	1180.	0.05	0.5	0.01	1.44	650.
4/21/82 2:40 p.m.	3900	53.	558.	0.04	0.8	B.D.[1]	0.89	404.
4/22/82 12:15 p.m.	2900	54.	422.	0.04	0.8	B.D.[1]	0.68	306.
4/23/82 1:15 p.m.	2250	46.	279.	0.05	1.1	B.D.[1]	0.62	279.
4/24/82 4:45 p.m.	1750	35.	165.	0.04	1.1	B.D.[1]	0.36	165.

B.D.[1] = Below Detection. Unless otherwise noted, the detection limit for PCB in the water-sediment samples is 0.03 parts per billion.

B.D.[2] = Below Detection. The detection limit for PCB in the nonfilterable suspended-solids samples varies as a function of the total residue present.

Figure 4-3

Woods Pond, By-Pass, and Schweitzer Holding Pond



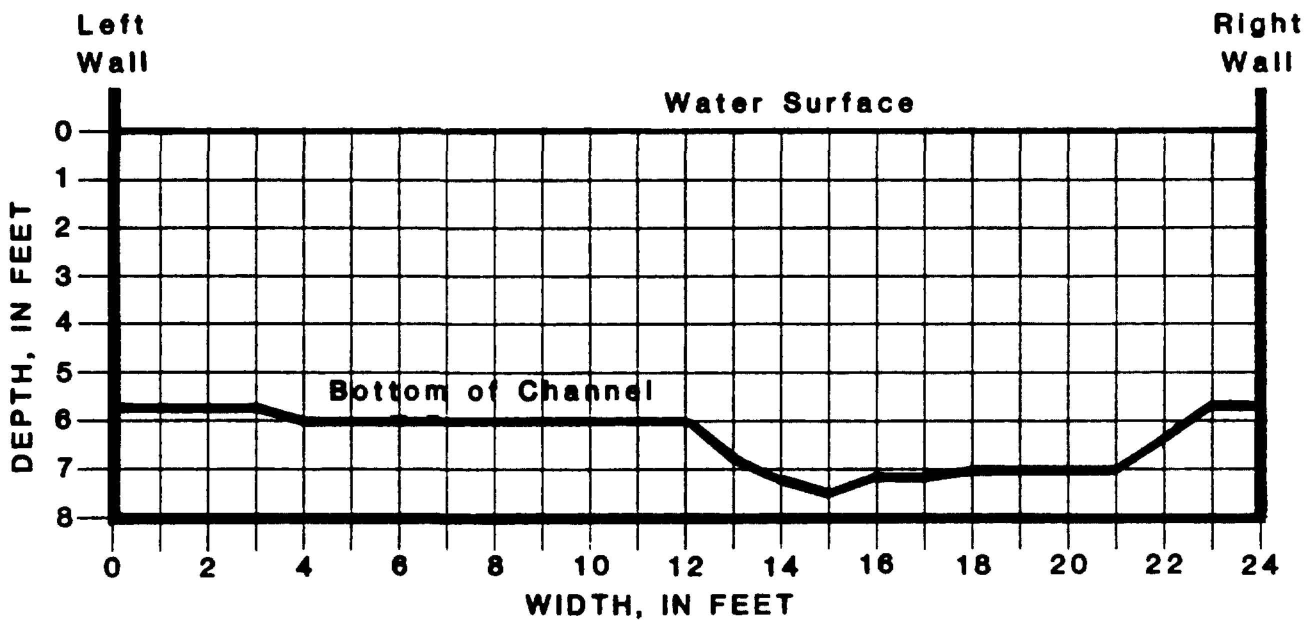


Figure 4-4

Channel Profile

Schweitzer By-Pass Canal, Facing Downstream

Table 4-22. Schweitzer By-pass Canal - Transport Data Summary

Date and Time	Instantaneous Dischange (ft^3/Sec)	Nonfilterable Suspended Solids (ppm)	Suspended Solids Discharge (tons/day)	Nonfilterable PCB in Water-Sediment Sample (ppb)	PCB in Suspended Solids (ppm)	Filterable PCB in Water-Sediment Sample (ppb)	Estimated Total PCB Transported (lbs/day)	Estimated Total PCB Transported (gm/day)
3/16/82 4:30 p.m.	206†	4.0	2.22	0.01	2.5	B.D.	0.027	12.1
3/16/82 6:15 p.m.	372‡	4.0	4.02	0.04	10.	B.D.	0.19	87.
4/23/82 6:15 p.m.	423‡	2.8	3.20	0.06	21.	0.04	0.55	248.

+ = Gates one-half open.

‡ = Gates full open.

B.D. = Below Detection. Unless otherwise noted, the detection limit for PCB in the water-sediment samples is 0.03 parts per billion.

was beyound their control during the April storm event. Field observation records indicate that the sluice gates were maintained wide-open throughout the high water study period.

The nature of sediment delivery to and through the by-pass canal is not fully understood. However, all data obtained to date indicate that PCBs are in effect "pulled" from Woods Pond and discharged from the by-pass canal into the Housatonic River whenever the sluice gates are opened. This "pulling" effect, especially during times of low flow, probably accounts for the lack of sediment deposition in the river channel in Station S18N and near the face of Woods Pond Dam itself (see Figure 4-3). The random control of water discharge through the Schweitzer by-pass adds much uncertainty to PCB transport interpretations.

4.4 Transport of PCBs in the Housatonic River

An evaluation of the data collected during the three events revealed that PCB transport in the Housatonic River is complex, but is associated with at least three different phenomena. Depending upon the magnitude of stream flow, the relative importance of each phenomenon to PCB transport rate varies. Specifically, PCB transport accompanies the movement of one or more of the following vehicles:

(1) PCB-laden nonfilterable suspended sediments resuspended from bottom deposits,

(2) discrete, non-sediment, PCB-contaminated materials including algae and aquatic plants, and

(3) filterable PCBs in the water column.

The experimental data confirm that the major mode of PCB transport under the study conditions is that associated with the deposition, resuspension, and redeposition of fine-grained particles containing sorbed PCBs. Consequently, the first phase of data evaluation included a traditional statistical computation of suspended-solids transport and its relation to PCB transport. The second phase of data evaluation deals with the two remaining transport modes.

4.4.1 Suspended-Solids Transport.

Although transport mechanisms and rates are complex and variable, certain data-analysis techniques can be applied to various components of the transport phenomena. Particularly, this investigation has shown that PCB transport as a function of nonfilterable suspended-solids can be estimated through the application of standard hydrologic engineering techniques. The data-analysis methods used here integrate statistically predictable streamflow rates and suspended-solids transport rates for the purpose of correlating that integral with variable PCB concentrations. A streamflow frequency analysis based on long-term data is used to assist in describing suspended solids transport along the reach of the Housatonic River from Pittsfield, Massachusetts downstream to the Connecticut state line. Basic references, supportive methodology and pertinent computational details are in Appendix 4-4.

4.4.1.1 Annual Suspended-Solids Transport Rates. Stream-discharge data from the USGS gaging station near Great Barrington serve as the basis for evaluating stream discharge at other points along the river. Although more than fifty years of streamflow data are available for this station, the period of record evaluated for this investigation was 1961-80. This time frame should represent the river system as it is today and provide a statistically valid data-base. Although hydrologic characteristics of the Housatonic River at Lenoxdale are quite different from those of the river at Andrus Road bridge, the centrally located gaging station near Great Barrington is representative of a transition segment between the upstream and downstream reaches of the river. Great Barrington data are useful for evaluating and relating streamflow characteristics at the upstream inflow station to those of the downstream outflow station. (Norvitch, 1968).

Numerous data transformations were required before a PCB discharge rate could be developed for the three river stations. The initial task involved synthesizing stream-discharge or flow-frequency curves for the Schweitzer bridge and Andrus Road bridge sites (Figure 4-5) utilizing the long-term streamflow for the Great Barrington site. More than 7,300 mean daily discharge values serve as the basis of the flow-duration curve for Great Barrington shown in Figure 4-6. Flow-duration curves for the East Branch at Coltsville, Massachusetts and the Housatonic River at Falls Village, Connecticut are also shown for comparative purposes. A streamflow analysis performed during this investigation showed that neither drainage-area ratios nor mean annual flows are satisfactory for extrapolation of the data for the Great Barrington gage to the short-term sites. The method described by Sercy (1959) was used for synthesizing flow-duration curves for both short-term stations (Appendix 4-3).

Suspended-solids transport curves were then developed for all three sites (Figures 4-7 to 4-9) to define the average relation between flow discharge and suspended-solids discharge. For this study, transport curves were <u>not</u> synthesized but, instead, were built on actual data points representing

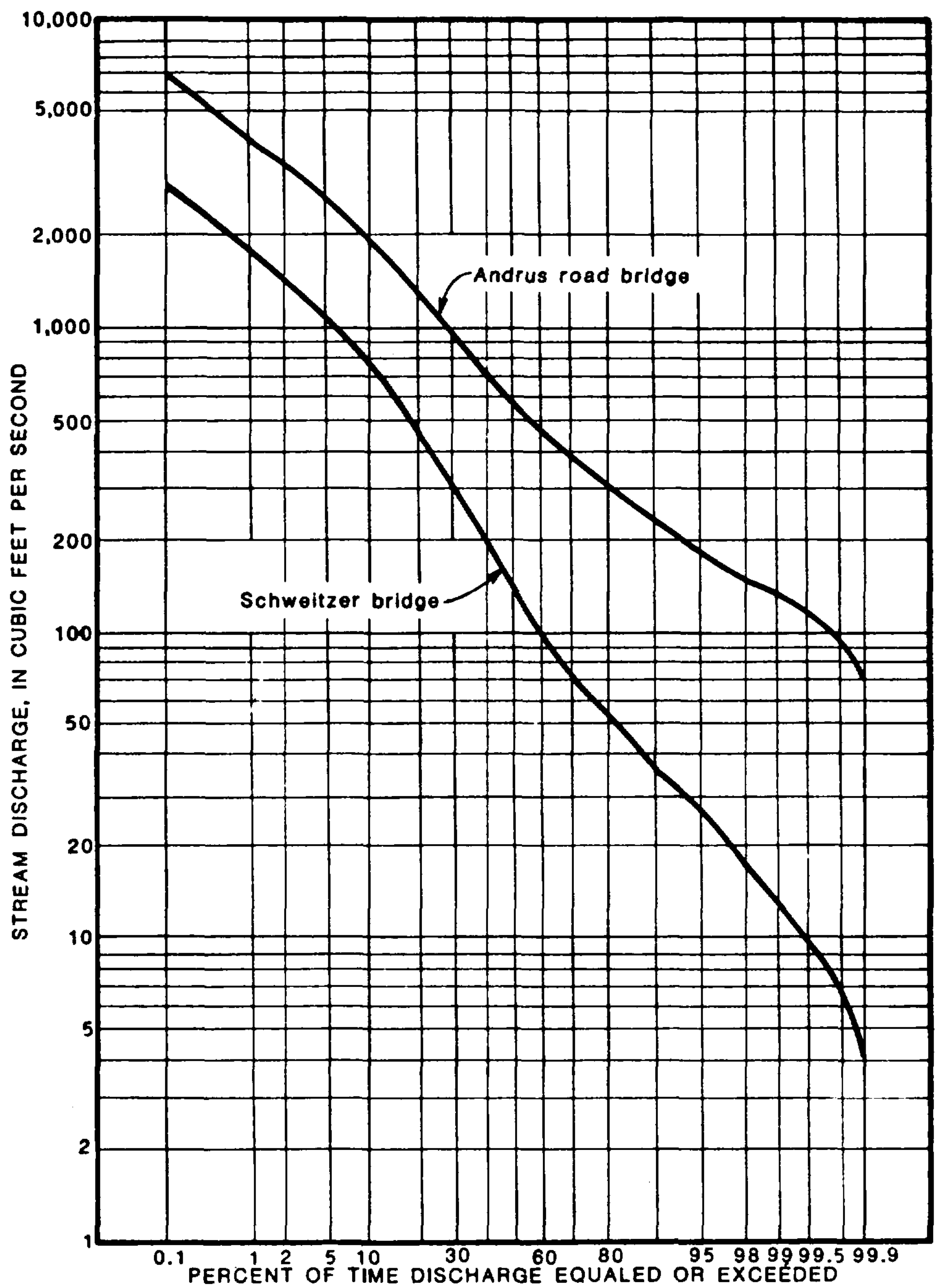


Figure 4-5

Duration Curves of Stream Discharge for the Housatonic River at Schweitzer Bridge and Andrus Road Bridge

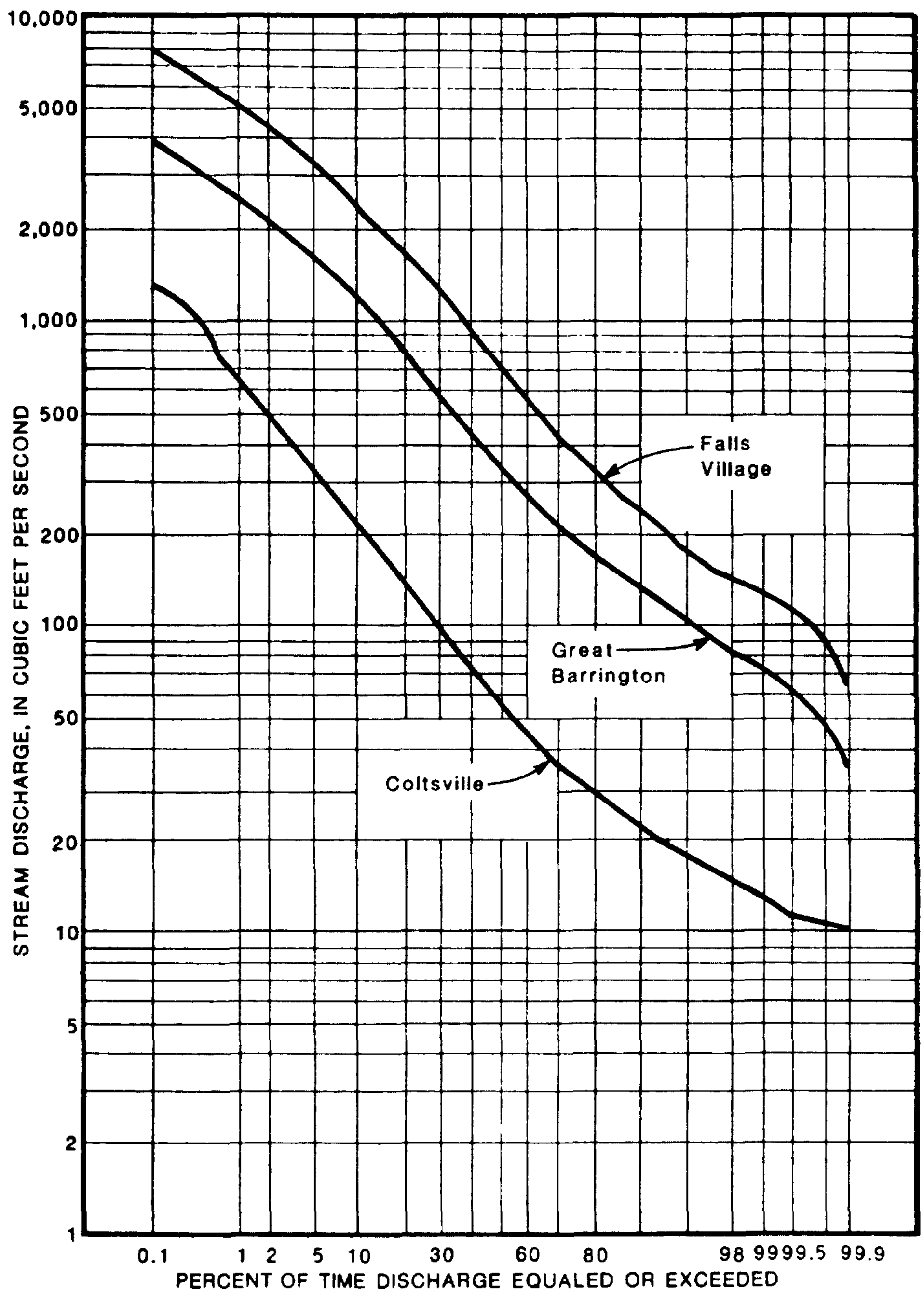


Figure 4-6

Duration Curves of Stream Discharge for Selected Stations Along the Upper Housatonic River

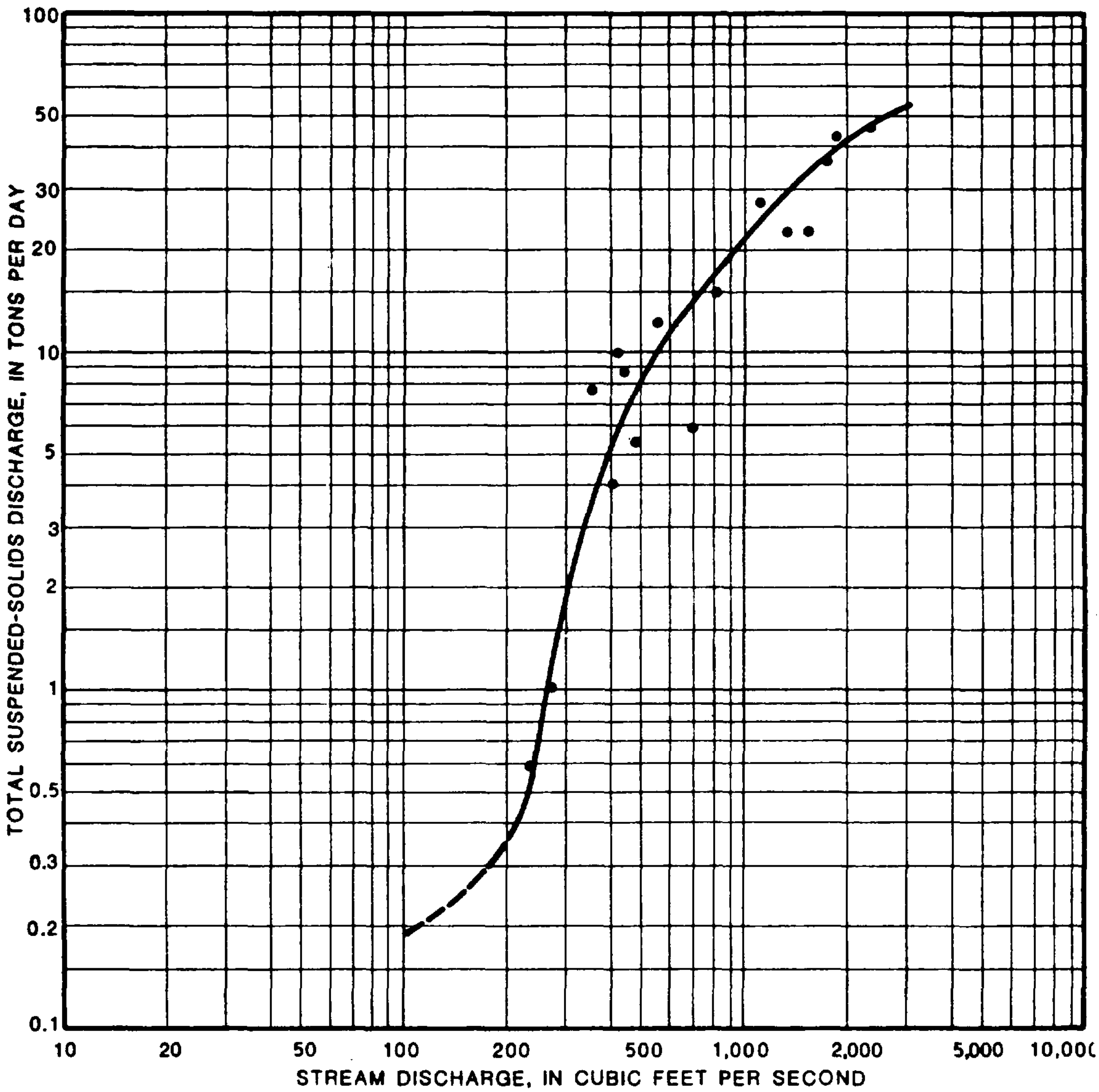


Figure 4-7

Suspended-Solids Transport Curve for the Housatonic River at Schweitzer Bridge

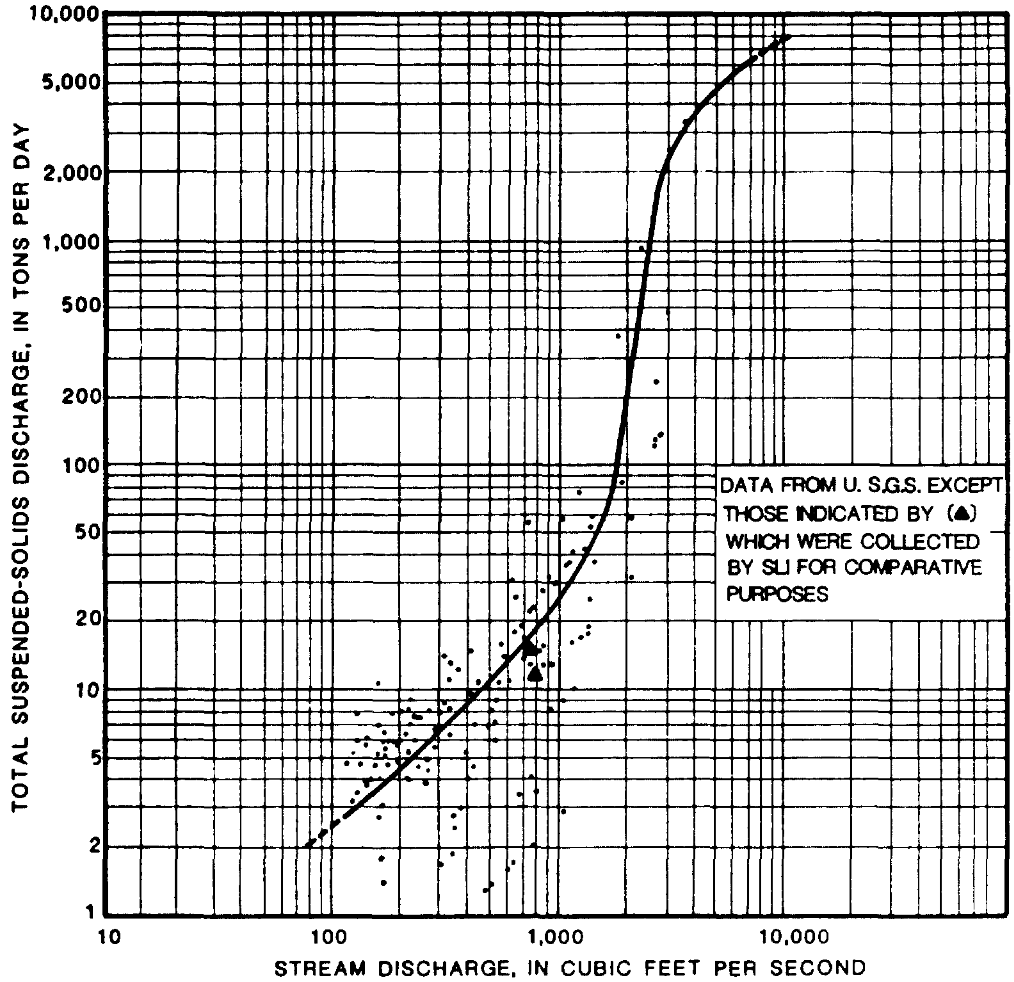


Figure 4-8

Suspended-Solids Transport Curve for the Housatonic River Near Great Barrington

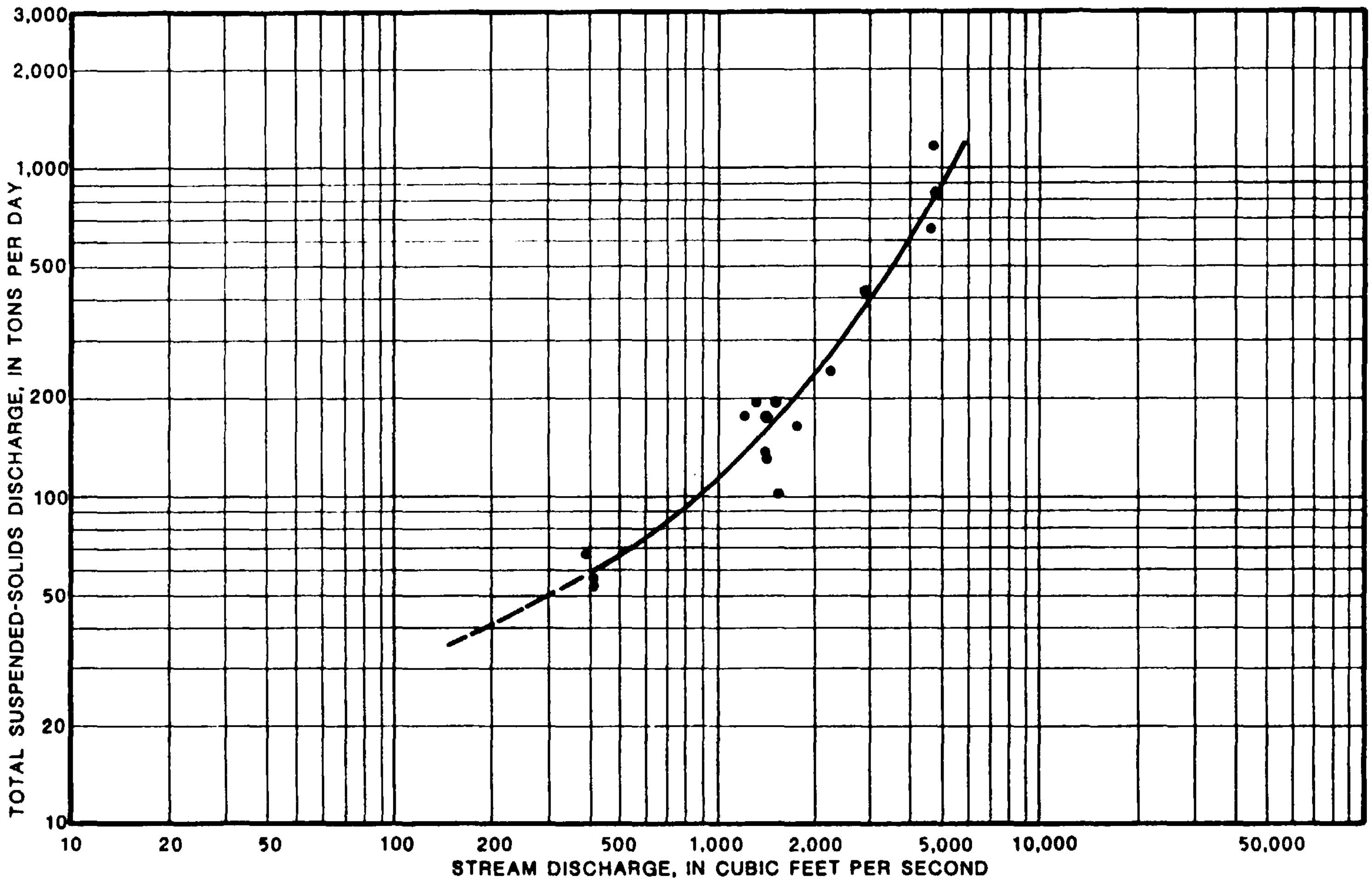


Figure 4-9

Suspended-Solids Transport Curve for the Housatonic River at Andrus Road Bridge

instantaneous stream-discharge rates and suspended-solids concentrations. The flow-duration curve, when used in conjunction with the transport curve, is appropriate for projecting a statistically meaningful distribution of water and suspended-solids discharge over an extended period of time. The procedure is superior to that of using fixed flow rates and average suspended-solids concentrations because it includes a compensation for streamflow variation. The methods of Guy (1964) and Porterfield (1972) are described in greater detail in Appendix 4-3.

A computation was made of mean daily suspended-solids discharge for the three transport stations (Tables 4-23 to 4-25). The tables represent the arithmatic integral of the stream-discharge duration curve and the suspended-solids transport curve for each station. The computation is based upon the frequency of a given magnitude of stream discharge and its corresponding average suspended-solids discharge. (See Appendix 4-3 for computation details). Suspended-solids discharge for the three transport sites is summarized in Table 4-26. Yearly mean values are obtained by multiplying the daily mean by 365.25. Unit-yield values are obtained by dividing the yearly value by the drainage area shown in column 1.

<u>4.4.1.2 Annual Suspended-Solids/PCB Transport Rates.</u> Data from the transport investigations indicate that, within given streamflow-range, a well-defined correlation exists between the quantity of nonfilterable (>1.5 micron) PCB load and the quantity of suspended solids in transport at any given time. The ratio of suspended PCBs and suspended solids varies both with stream discharge and suspended-solids discharge. However, the relationship for Great Barrington and

Table 4-23. Mean Daily Suspended-Solids Discharge for Housatonic River at Lenoxdale at Schweitzer Bridge

Percentage of Time in Selected Increments	Q_{H_2O}† Equaled or Exceeded (ft^3/sec)	Q_{SS}†† (tons per day)	Time Interval Evaluated (percent)	Mean Q_{SS} for Time Interval Evaluated (tons per day)	Mean Q_{SS} adjusted to one (1) percent (tons per day)
0.1	2,900	54	0.1	52	5
0.2	2,540	50	0.1	49	5
0.3	2,380	48	0.2	47	9
0.5	2,100	46	0.2	44	9
0.7	1,975	42	0.3	41	12
1.0	1,800	40	0.4	38	15
1.4	1,625	36	0.6	35	21
2.0	1,480	34	1.0	32	32
3.0	1,300	29	2.0	26	52
5.0	1,090	24	2.0	22	44
7.0	930	21	3.0	19	57
10.0	795	17	5.0	14	70
15.0	590	11	5.0	9	45
20.0	465	7	10.0	4	40
30.0	305	2	10.0	1	10
40.0	200	0	10.0	0	0
50.0	145	0	10.0	0	0
60.0	105	0	20.0	0	0
80.0	56	0	10.0	0	0
90.0	34	0	8.0	0	0
98.0	17	0	1.9	-	-
99.9	-	-	-	-	-

†Q_{H_2O} = Water Discharge

†† Q_{SS} = Suspended Solids Discharge

Total: 436

Mean Daily Q_{SS}=Total/100 = 4 tons/day

Table 4-24. Mean Daily Suspended-Solids Discharge for Housatonic River near Great Barrington

Percentage of Time in Selected Increments	Q_{H_2O}+ Equaled or Exceeded (ft^3/sec)	Q_{SS}++ (tons per day)	Time Interval Evaluated (percent)	Mean Q_{SS} for Time Interval Evaluated (tons per day)	Mean Q_{SS} adjusted to one (1) percent (tons per day)
0.1	3,900	3,300	0.1	2,950	295
0.2	3,500	2,600	0.1	2,425	243
0.3	3,225	2,250	0.2	1,875	375
0.5	2,925	1,500	0.2	1,400	280
0.7	2,750	1,300	0.3	990	297
1.0	2,510	680	0.4	550	220
1.4	2,320	420	0.6	330	198
2.0	2,125	240	1.0	175	175
3.0	1,900	110	2.0	82	164
5.0	1,610	54	2.0	50	100
7.0	1,425	47	3.0	40	120
10.0	1,210	33	5.0	28	140
15.0	955	22	5.0	20	100
20.0	780	17	10.0	14	140
30.0	570	11	10.0	10	100
40.0	420	8	10.0	8	80
50.0	335	7	10.0	6	60
60.0	270	5	20.0	5	100
80.0	173	4	10.0	4	35
90.0	130	3	8.0	2	20
98.0	83	2	1.9	-	-
99.9	-	-	-	-	-

Total: 3,242

Mean Daily Q_{SS}=Total/100 = 32 tons/day

+Q_{H_2O} = Water Discharge

++Q_{SS} = Suspended-Solids Discharge

at Andrus Road Bridge

Percentage of Time in Selected Increments	Q_{H_2O} Equaled or Exceeded (ft^3/sec)	Q_{SS}++ (tons per day)	Time Interval Evaluated (percent)	Mean Q_{SS} for Time Interval Evaluated (tons per day)	Mean Q_{SS} adjusted to one (1) percent (tons per day)
0.1	6,500	1,500	0.1	1,330	133
0.2	5,700	1,160	0.1	1,080	108
0.3	5,220	1,000	0.2	890	178
0.5	4,610	780	0.2	750	150
0.7	4,350	720	0.3	675	202
1.0	4,000	630	0.4	600	240
1.4	3,710	570	0.6	532	319
2.0	3,390	495	1.0	458	458
3.0	3,000	420	2.0	395	790
5.0	2,850	370	2.0	320	640
7.0	2,250	270	3.0	245	735
10.0	1,900	220	5.0	195	975
15.0	1,510	170	5.0	155	775
20.0	1,250	140	10.0	122	1,220
30.0	925	105	10.0	96	960
40.0	700	86	10.0	80	800
50.0	560	73	10.0	68	680
60.0	455	62	20.0	58	1,160
80.0	300	49	10.0	46	460
90.0	225	42	8.0	39	312
98.0	148	36	1.9	-	-
99.9	-	-	-	-	-

Total: 11,295

Mean Daily Q_{SS}=Total/100 = 113 tons/day

+Q_{H_2O} = Water Discharge

++Q_{SS} = Suspended Solids Discharge

Table 4-26

Summary of Suspended-Solids Discharge for the Upper

Housatonic River Basin in Massachusetts

Station	Drainage Area (mi^2)	Daily Mean Q_{SS}† (tons/day)	Yearly Mean Q_{SS}† (tons/year)	Unit Yield Q_{SS}† (tons/yr/mi^2)
Housatonic River at Lenoxdale at Schweitzer bridge	101	4	1,461	14
Housatonic River near Great Barrington	280	32	11,688	42
Housatonic River at Andrus Road bridge	471	113	41,273	88

† Q_{SS} = Suspended-Solids Discharge

Andrus Road is different from that observed at the Schweitzer site. There is a straight-line relation between the daily discharge of suspended PCBs and the daily discharge of suspended solids in the stream-discharge range of 250-2200 ft^3/sec at the Schweitzer site (Figure 4-10). Points on the graph represent the ratio of daily discharge of suspended PCBs in grams divided by the daily discharge of suspended solids in grams multiplied by a factor of 100,000 for plotting convenience. The upper portion of the curve was fitted visually, while the lower extension was projected toward base flow (30 ft^3/sec) for the Housatonic River at this location. Very little effort was made to extend the high-end of the ratio curve. However, flow rates exceeding 2500 ft^3/sec would occur only 0.2 percent of the time.

The ratio of suspended PCBs to suspended solids at Great Barrington are shown to correlate closely between flows of 1,000 and 3,000 ft^3/sec (Figure 4-11). Although no effort was made to extend the upper end of the curve, historical data correlating the highest water discharges with wide-spread upper basin storms would suggest that the ratio would continue to decrease as shown. Overland runoff resulting from wide-spread precipitation events would cause a dilution effect due to the influx of uncontaminated suspended sediment. Extension of the low-flow segment of the curve is based on the assumption that at base flow, suspended-sediment as well as nonfilterable PCB transport is at or near zero. Base flow for Great Barrington was determined to be 108 ft^3/sec.

At the Andrus Road site, the ratio of suspended PCBs to suspended-solids discharge is closely correlated between flow ranges of 1500 and 4000 ft^3/sec. For flows greater than 4000 ft^3/sec, the data points in Figure 4-12 become more scattered. Presumably, the dilution effects of non-contaminated sediments from

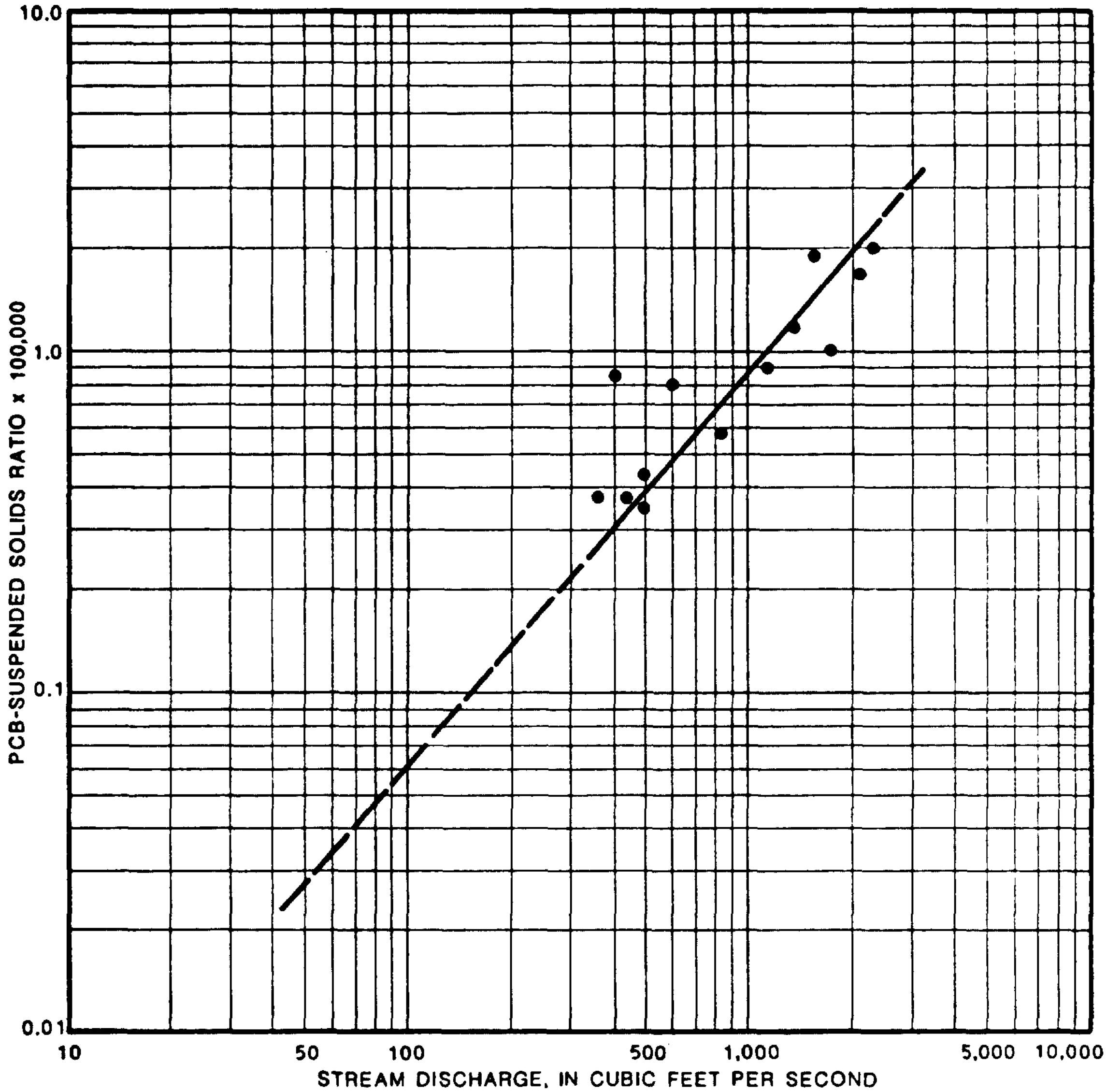


Figure 4-10

Relation of PCB-Suspended Solids Ratio to Stream Discharge for the Housatonic River at the Schweitzer Bridge

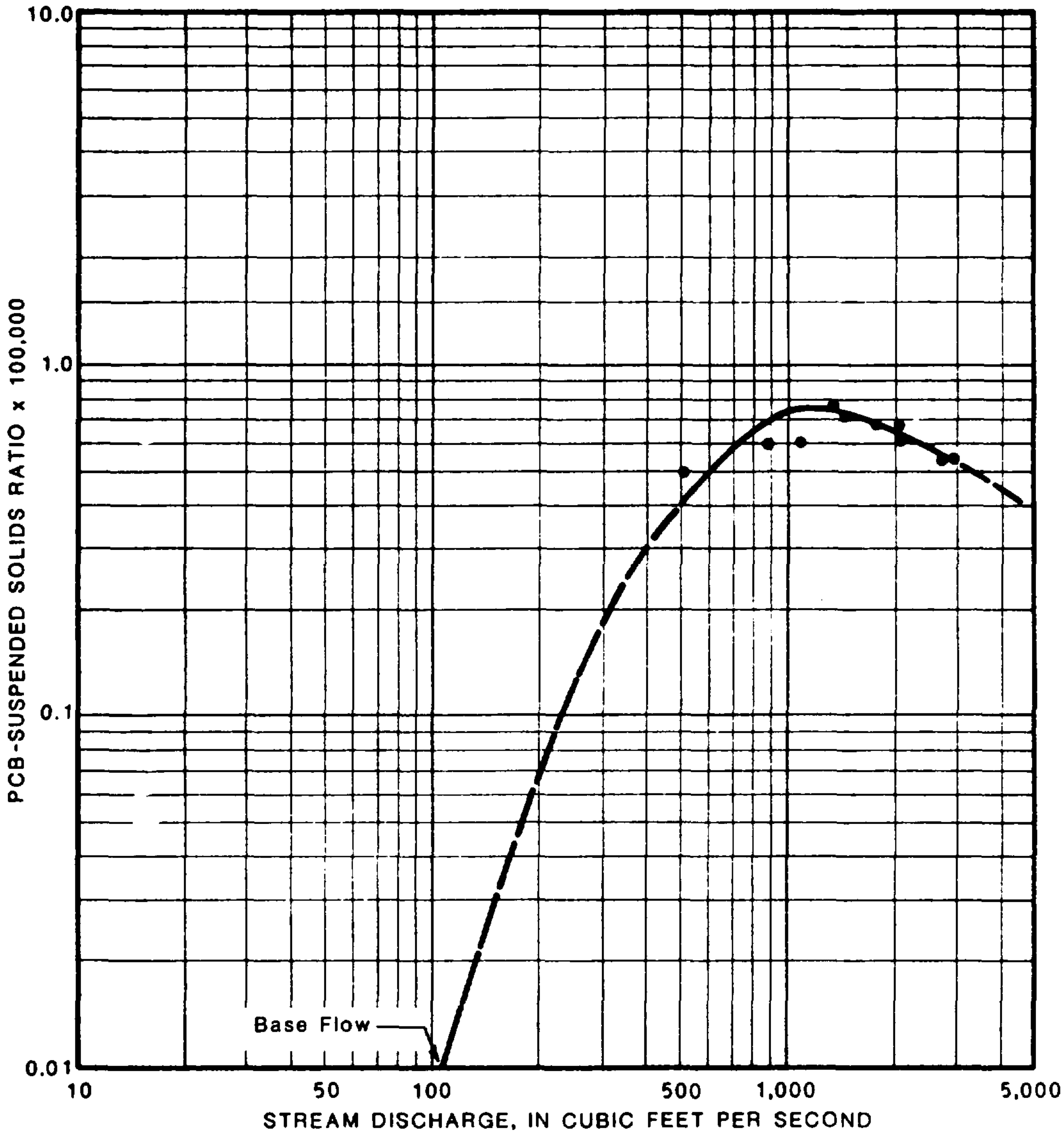


Figure 4-11

Relation of PCB-Suspended Solids Ratio to Stream Discharge for the Housatonic River Near Great Barrington

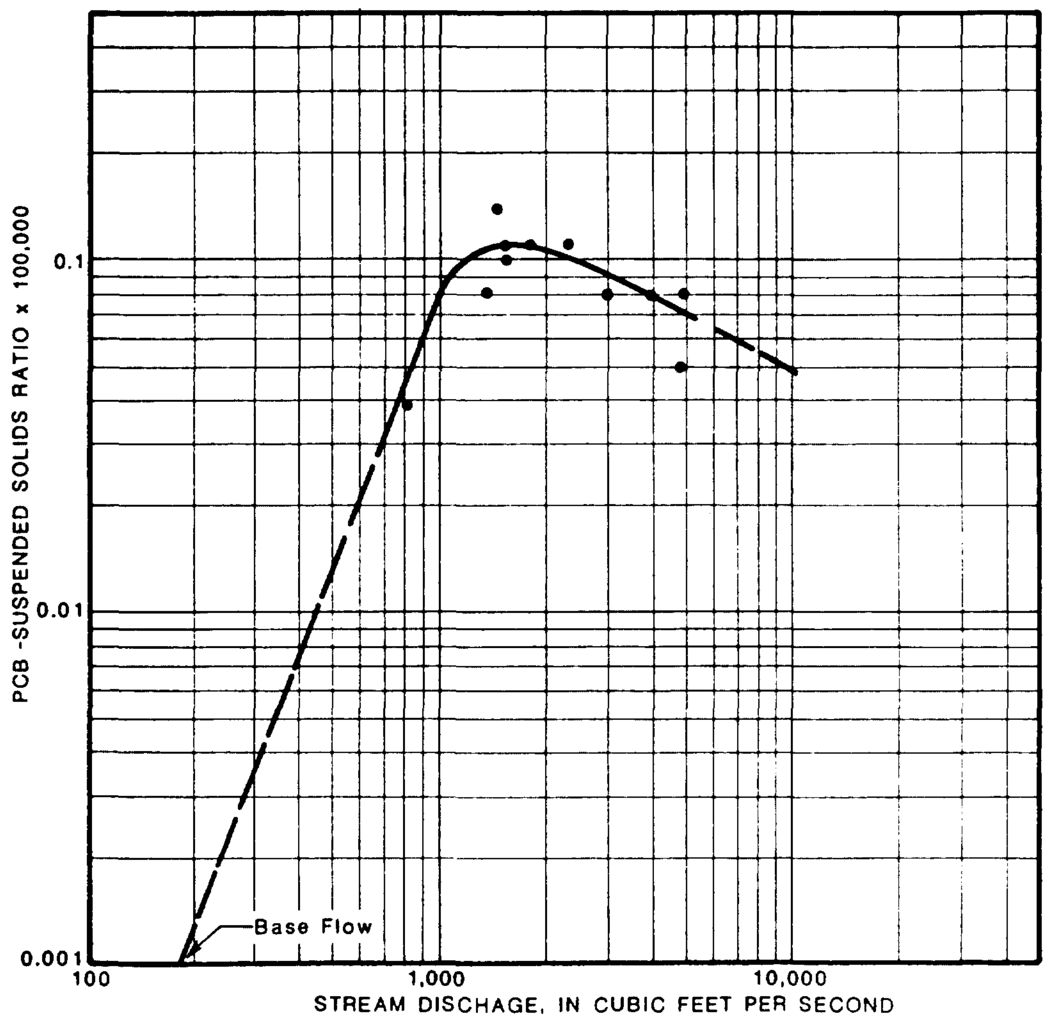


Figure 4-12

Relation of PCB-Suspended Solids Ratio to Stream Discharge for the Housatonic River at Andrus Road Bridge

farmland between Great Barrington and Andrus Road bridge influence the high-flow region of the curve. The low-flow end of the curve was extended toward base-flow of 180 ft^3/sec. in a manner similiar to that used for Great Barrington.

The data analyses presented in this section are designed to evaluate the influence of streamflow magnitudes and variable PCB-suspended solids ratios upon PCB transport. The methodology as designed applies an average ratio to the average suspended-solids discharge, thereby providing an estimate of PCB discharge. The method is inherently statistical, but it affords a means of projecting PCB transport with regard to streamflows which have occurred during a long-term period.

A duration curve of the PCB-suspended solids ratio for the Schweitzer bridge site is illustrated in Figure 4-13. The curve was drawn by relating the ratio values, shown in Figure 4-10, to statistically predictable streamflow rates for discrete time intervals from the duration curve for the site (Figure 4-5). Suspended PCB discharge computations for the Schweitzer site are found in Table 4-27. The unadjusted mean daily ratio is obtained by dividing the total of the column number 5 by 100 to factor out the percentage entity. The adjusted mean daily ratio is obtained by removing the multiplier of 100,000 originally used for convenience in plotting the data. Daily PCB discharge is obtained by multiplying the adjusted mean daily ratio times the total daily discharge of suspended solids expressed as grams per day. This statistical approach predicts a suspended PCB discharge for the Schweitzer Bridge site of 8.7 grams/day or 7.0 pounds/year.

PCB suspended-solids ratio duration curves for the Great Barrington and Andrus Road sites are illustrated in Figures 4-14 and 4-15, respectively. The basis

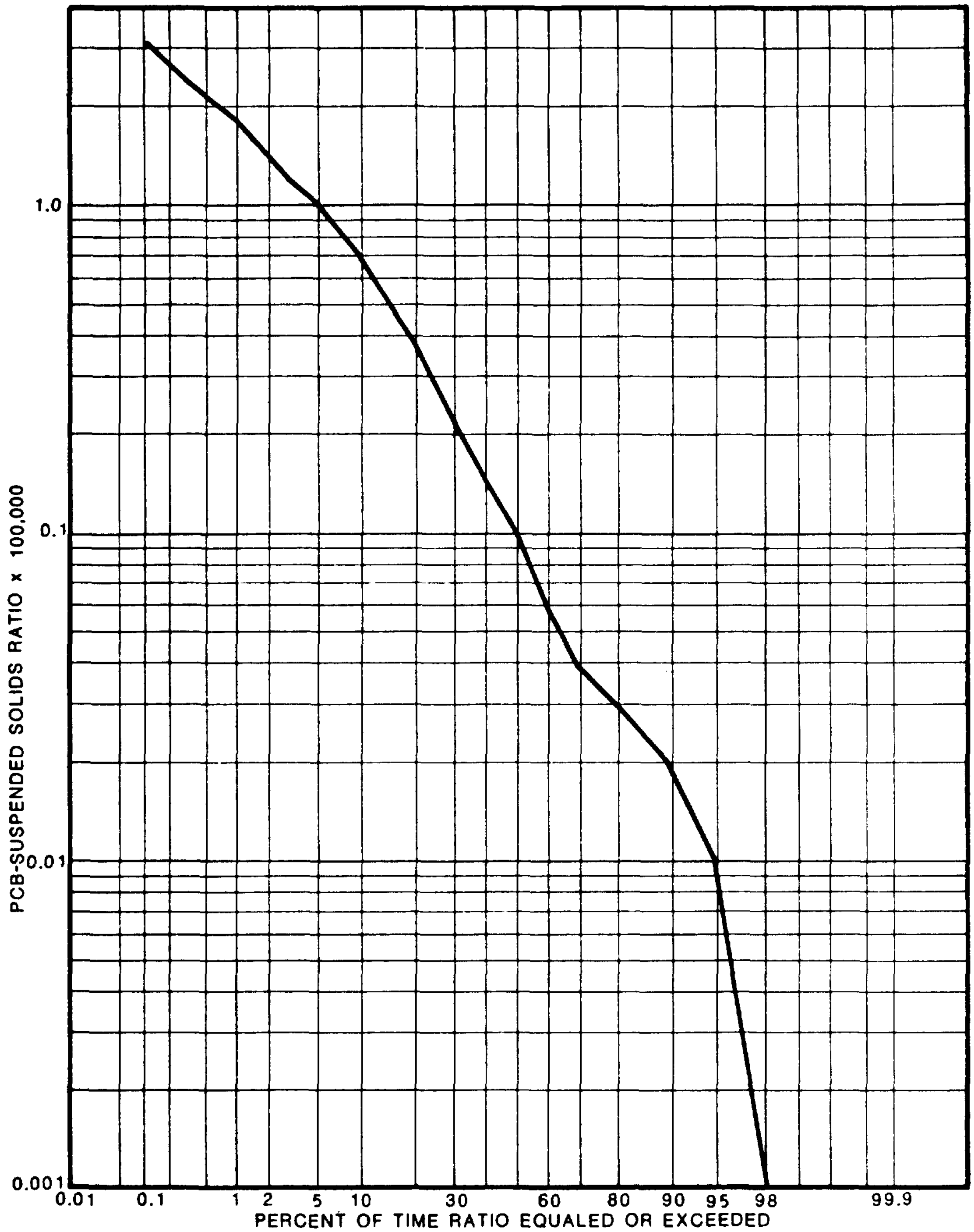


Figure 4-13

Duration Curve of PCB-Suspended Solids Ratio for the Housatonic River at the Schweitzer Bridge

Table 4-27 Computation of suspended PCB discharge for the Housatonic River at Lenoxdale at Schweitzer bridge.

rcentage of time in selected ncrements	PCB-suspended solids ratio (x100,000)	Time Interval evaluated (percent)	Mean Ratio for time interval evaluated	Ratio adjusted to one (1) percent
0.1	3.1	0.1	2.90	0.29
0.2	2.7	0.1	2.60	0.26
0.3	2.4	0.2	2.20	0.44
0.5	2.1	0.2	2.10	0.42
0.7	2.0	0.3	1.90	0.57
1.0	1.8	0.4	1.70	0.68
1.4	1.6	0.6	1.50	0.90
2.0	1.4	1.0	1.30	1.30
3.0	1.2	2.0	1.10	2.20
5.0	1.0	2.0	0.92	1.84
7.0	0.83	3.0	0.75	2.25
10.0	0.67	5.0	0.58	2.90
15.0	0.49	5.0	0.44	2.20
20.0	0.38	10.0	0.30	3.00
30.0	0.22	10.0	0.18	1.80
40.0	0.14	10.0	0.12	1.20
50.0	0.10	10.0	0.08	0.80
60.0	0.06	20.0	0.04	0.80
80.0	0.03	10.0	0.02	0.20
90.0	0.02	8.0	0.01	0.08
98.0	0.00	-	-	-
			Total	24.13 (in percent)

Unadjusted Mean Daily Ratio = total/100 = 0.2413

Adjusted Mean Daily Ratio = 0.2400/100,000 = 0.0000024

Daily PCB discharge = 0.0000024x3,632,000 grams/day of suspended solids

= 8.7 grams/day

= 7.0 pounds/year

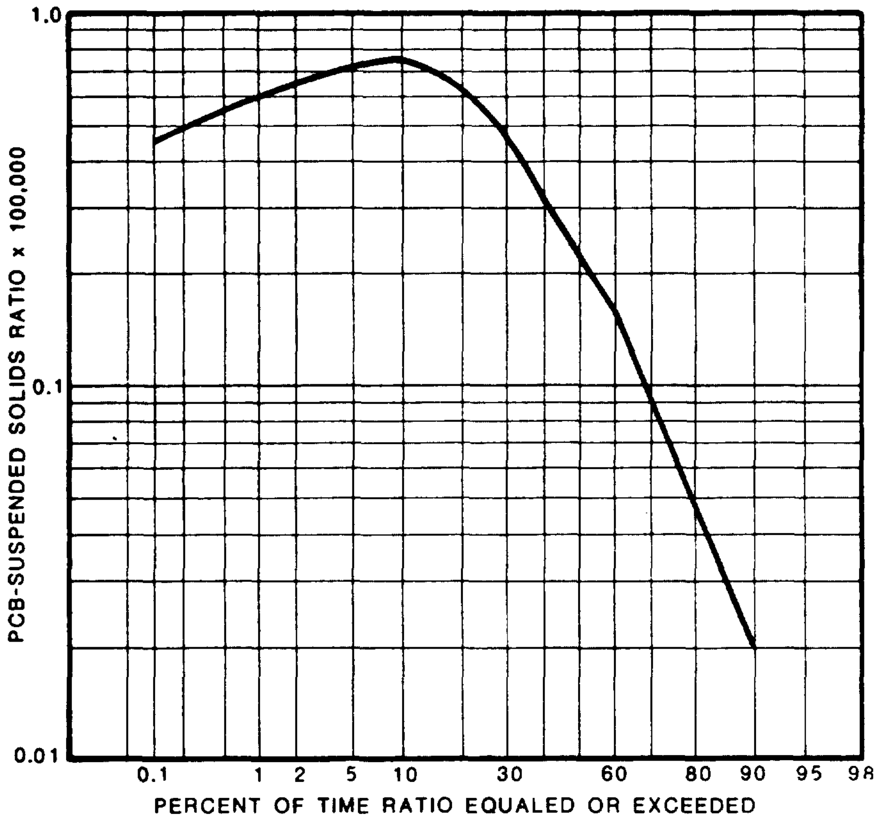


Figure 4-14

Duration Curve of PCB-Suspended Solids Ratio for the Housatonic River Near Great Barrington

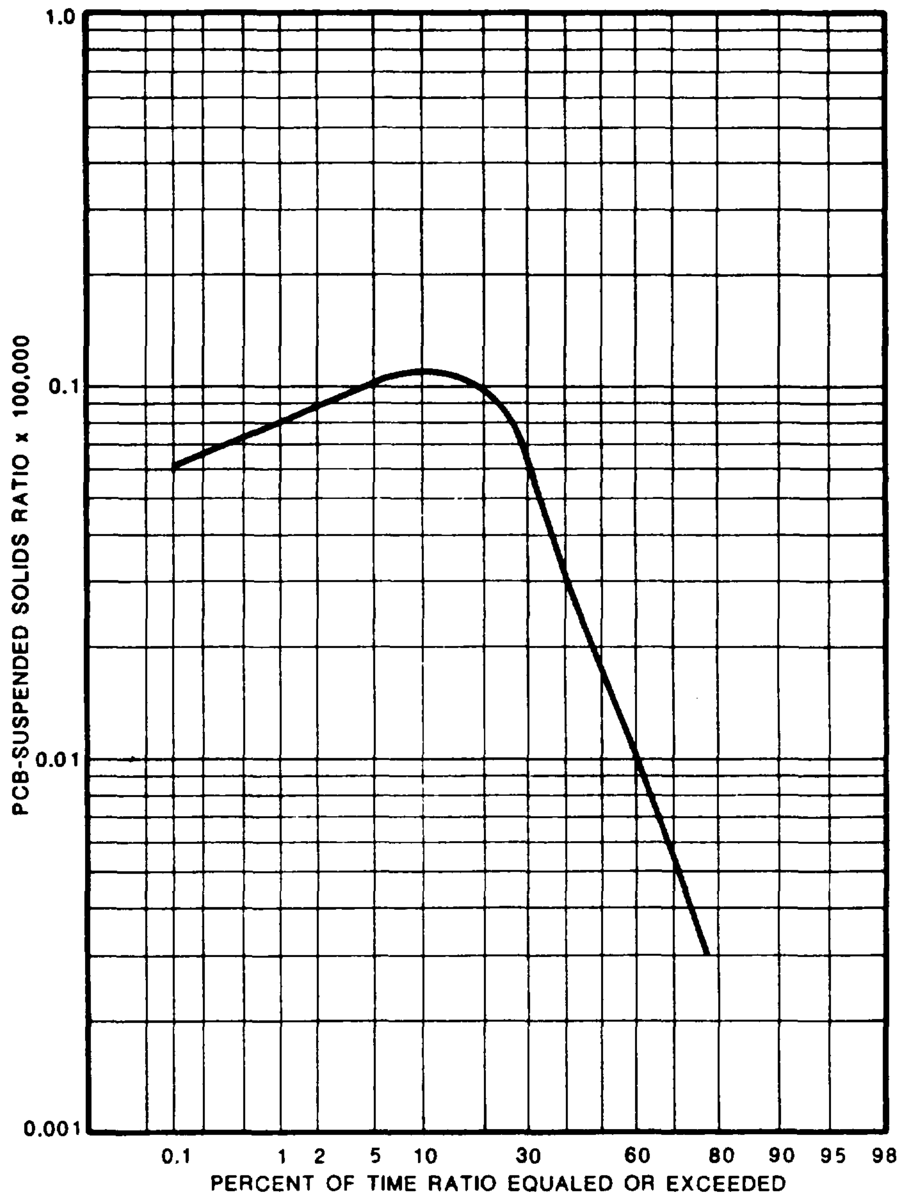


Figure 4-15

Duration Curve of PCB-Suspended Solids Ratio for the Housatonic River at the Andrus Road Bridge

for computing the suspended PCB discharge rates for these same sites are found in Tables 4-28 and 4-29.

A summary of suspended PCB discharge loads for the three transport sites in the Upper Housatonic River Basin is found in Table 4-30. The design primacy for the study was to define the "worst case" situation. For this reason, the PCB loads calculated for Table 4-30 are based on <u>all</u> stream flow conditions. Actually, there is no experimental evidence which indicates that PCBs are in transport under low flow conditions. A more realistic approximation of the PCB transport load for Great Barrington and Andrus Road would exclude from consideration periods of flow <500 ft^3/sec and <750 ft^3/sec, respectively. This would reduce the calculated PCB load to 55 lbs/year for Great Barrington and 27 lbs/year at Andrus Road. Further discussion relative to the significance of these findings is found in Section 4.5.

Table 4-30. Summary of Suspended PCB Discharge for the Upper Housatonic River in Massachusetts

Station	Drainage Area (mi^2)	Daily Mean PCB grams/day)	Yearly Mean PCB (pounds/year)	Unit Yield PCB (pounds/year/mi^2)
Housatonic River at Lenoxdale at Schweitzer bridge	101	8.7	7.0	0.07
Housatonic River near Great Barrington	280	87	70	0.25
Housatonic River at Andrus Road bridge	471	41	33	0.07

Table 4-28. Computation of suspended PCB discharge for the Housatonic River near Great Barrington.

rcentage of time in selected ncrements	PCB-suspended solids ratio (x100,000)	Time Interval evaluated (percent)	Mean Ratio for time interval evaluated	Ratio adjusted to one (1) percent
0.1	0.46	0.1	0.48	0.05
0.2	0.49	0.1	0.50	0.05
0.3	0.51	0.2	0.53	0.10
0.5	0.55	0.2	0.56	0.11
0.7	0.56	0.3	0.57	0.17
1.0	0.58	0.4	0.60	0.24
1.4	0.61	0.6	0.62	0.37
2.0	0.63	1.0	0.65	0.65
3.0	0.67	2.0	0.69	1.38
5.0	0.71	2.0	0.73	1.46
7.0	0.75	3.0	0.76	2.28
10.0	0.77	5.0	0.74	3.70
15.0	0.70	5.0	0.67	3.35
20.0	0.64	10.0	0.56	5.60
30.0	0.48	10.0	0.40	4.00
40.0	0.33	10.0	0.28	2.80
50.0	0.23	10.0	0.20	2.00
60.0	0.16	20.0	0.10	2.00
80.0	0.05	10.0	0.04	0.40
90.0	0.02	8.0	-	-
98.0	-	-	-	-

Total 30.7 (in percent)

Unadjusted Mean Daily Ratio = Total/100 = 0.3071

Adjusted Mean Daily Ratio = 0.3100/100,000 = 0.000003

Daily PCB discharge = 0.000003x29,056,000 grams/day of suspended solids

= 87 grams/day

= 70 pounds/year

Table 4-29 - Computation of suspended PCB discharge for the Housatonic River at Andrus road bridge.

Percentage of time in selected increments	PCB-suspended solids ratio (x100,000)	Time Interval evaluated (percent)	Mean Ratio for time interval evaluated	Ratio adjusted to one (1) percent
0.1	0.06	0.1	0.06	0.01
0.2	0.06	0.1	0.06	0.01
0.3	0.07	0.2	0.07	0.01
0.5	0.07	0.2	0.07	0.01
0.7	0.07	0.3	0.08	0.02
1.0	0.08	0.4	0.08	0.03
1.4	0.08	0.6	0.09	0.05
2.0	0.09	1.0	0.09	0.09
3.0	0.09	2.0	0.10	0.20
5.0	0.10	2.0	0.10	0.20
7.0	0.10	3.0	0.11	0.33
10.0	0.11	5.0	0.11	0.55
15.0	0.11	5.0	0.10	0.50
20.0	0.10	10.0	0.08	0.80
30.0	0.06	10.0	0.05	0.50
40.0	0.03	10.0	0.03	0.30
50.0	0.02	10.0	0.02	0.20
60.0	0.01	20.0	0.01	0.20
80.0	0.00	10.0	0.00	0.00
90.0	0.00	8.0	0.00	0.00
98.0	0.00	-	-	-
				Total 4.01 (in percent)

Unadjusted Mean Daily Ratio = total/100 = 0.0401

Adjusted Mean Daily Ratio = 0.04/100,000 = 0.0000004

Daily PCB discharge = $0.0000004 \times 1.026 \times 10^8$ grams/day of suspended solids

= 41 grams/day

= 33 pounds/year

4.4.2 PCB Transport Modes.

The preceeding section has dealt with the application of statistically developed sediment transport theories to PCB transport associated with suspended-solids. This section describes two additional transport modes which were observed during the 1982 investigations.

4.4.2.1 PCB Transport by Way of Discrete, Non-sediment Materials. By definition, sediment refers to particles of soil, rock and organic materials which are found deposited in the stream bed. They are frequently quite similar to the material that forms the stream bank. Sediment particles vary in specific gravity and mineral composition, the predominate mineral being quartz. The suspended-solids considered in Section 4.4.1 were predominantly inorganic sediment. The suspended material which is the topic of this discussion has distinctively different physical and chemical characteristics. These discrete, suspended materials are primarily organic in nature and are usually green or brown. Materials identified included algae, pieces of green plant, decaying plant as well as brownish, fluffy residues. Size of the materials varies considerably, and pieces up to two inches in length were observed. The materials are rather stringy in nature; and although they do not float on the water surface, they remain suspended in the water by the movement of the current for appreciable lengths of time.

The only mode of PCB transport detected during the winter background study in February 1982, was that associated with these discrete materials. Movement of these materials was sporadic, and their distribution in the water column was random. The PCB content of these suspended non-sediment materials varied from 11 to 20 ppm.

It is significant to note that this transport phenomenon was observed only at the Schweitzer Bridge location and only when the sluice gates were opened fully, and water was allowed to discharge directly from Woods Pond through the by-pass channel around Woods Pond dam. Based on instantaneous discharge measurements for this condition, the sediment load was 4.2 tons/day and the PCB discharge was 30. grams (0.067 pounds/day).

4.4.2.2 Transport as Filterable PCBs in the Water Column. This mode of PCB transport occurred at all three Housatonic River stations and at the Woods Pond by-pass sampling site during the April 1982 storm event. By way of clarification, the particle size associated with the suspended materials previously discussed in Sections 4.4.1 and 4.4.2.1 is greater than 1.5 microns. This is the material which is retained on the filter used for the suspended solids determination. The filterable fraction of the sediment-water mixture is that sample which passed through the filter and, by filter exclusion, has particle sizes less than 1.5 microns. This fraction would contain insoluble materials classified as medium to fine clays, very fine clay, and colloids in addition to materials which are soluble and are in true solution.

A summary of all experimental data relating to the presence of filterable PCBs in the water columns is found in Table 4-31. Even though the amount of data collected during the transport study relating to filterable PCB concentrations is limited, an estimation of the duration of this transport mode can be made utilizing the flow duration curves developed for this study. For the Schweitzer bridge site, filterable PCB concentrations were noted for all discharges, >700 ft^3/sec. Duration of streamflow for this level is 12 percent.

Table 4-31. Filterable PCB Data Summary

Location	Date	Event	Filterable PCB Cover Range Observed (ppt)	% Filterable PCB in Water-Sediment Sample	Instantaneous Discharge (ft^3/sec)
By-pass Canal	April, 1982	Storm	40.	40.	>420
Schweitzer bridge	April, 1982	Storm	20.- 80.	33.	>700
Gt.Barrington bridge	April, 1982	Storm	0-40.	27.	>1750
Andrus Road bridge	April, 1982	Storm	0-10.	8.	>3900
Woods Pond	June, 1982	Simulated Storm	70.	-	-

Filterable PCBs were detected at the Great Barrington bridge site for all discharges >1,750 ft^3/sec or a duration of streamflow of 4 percent. Streamflow levels of >3,900 ft^3/sec were required at the Andrus road bridge site before filterable PCB concentrations were detected. Streamflow duration for this level is 1 percent.

The magnitude of the filterable PCB discharge observed for the April 1982 storm event follows: Schweitzer, 1.8 pounds; Great Barrington, 1.0 pound; and Andrus Road, 0.4 pound.

The most likely source of the filterable PCB in the water column is the sediment-water interface in the more quiescent reaches of Woods Pond and Station 17. Since this phenomenon occurs only during periods of high flow, it does not appear to be the same situation which has been observed in the Hudson River during periods of low streamflow, when dissolved PCB (Aroclor 1242) occurs in the water column at concentrations of 1 ppb (1). According to Monsanto(2), the solubility of PCBs in water is low and decreases with increasing chlorine content. Aroclor 1254 and Aroclor 1260 (the major PCBs in the Housatonic River) are 5 to 10 times less soluble than Aroclor 1242.

4.5 Discussion of Results

There is an apparent incompatibility of results when annual PCB transport projections from the historically based, statistically derived treatment (Table 4-30) are compared to the short-term, isolated event experimental data based on instantaneous discharge computations (Table 4-18). They are, actually, complementary techniques. One obtains in-depth information from the isolated event. However, a realistic overview of PCB transport requires an approach where flow-rate projections are automatically adjusted to account for extended periods of low streamflow and brief periods of high streamflow.

4.5.1 Relationship of PCB Concentration to Streamflow.

Experimental data obtained from the discrete, short-term studies are plotted for the three transport locations in Figures 4-16 and 4-17. A plot of PCB concentration in the suspended sediment vs flow is shown in Figure 4-16. The relationship between the PCB concentration of the water-sediment mixture (total PCB concentration) and flow is plotted as Figure 4-17. These data indicate that within the flow ranges of the study, the amount of PCB transported at Schweitzer bridge is directly related to stream discharge.

The situation at the Great Barrington gage is not nearly as straightforward. There does appear to be a direct relationship between total PCB concentration of the water-sediment mixture and flow under the study conditions. However, the plot of PCB concentration in the suspended sediment vs flow shows the effect of dilution with "clean" sediment as discharge increases.

The over-all dilution effect resulting from the influx of non-PCB containing sediments is especially apparent at Andrus Road bridge, where both the concentration of PCBs in the suspended sediment as well as the total PCB concentration in the water-sediment mixture are essentially constant at 1 ppm and 50 ppt, respectively (see Figures 4-16 and 4-17).

4.5.2 Suspended-Solids Loading and Transport Rates.

Because of the variability of the geology and the distribution of soils in the Upper Housatonic River Basin, it is not surprising that suspended-solids loading

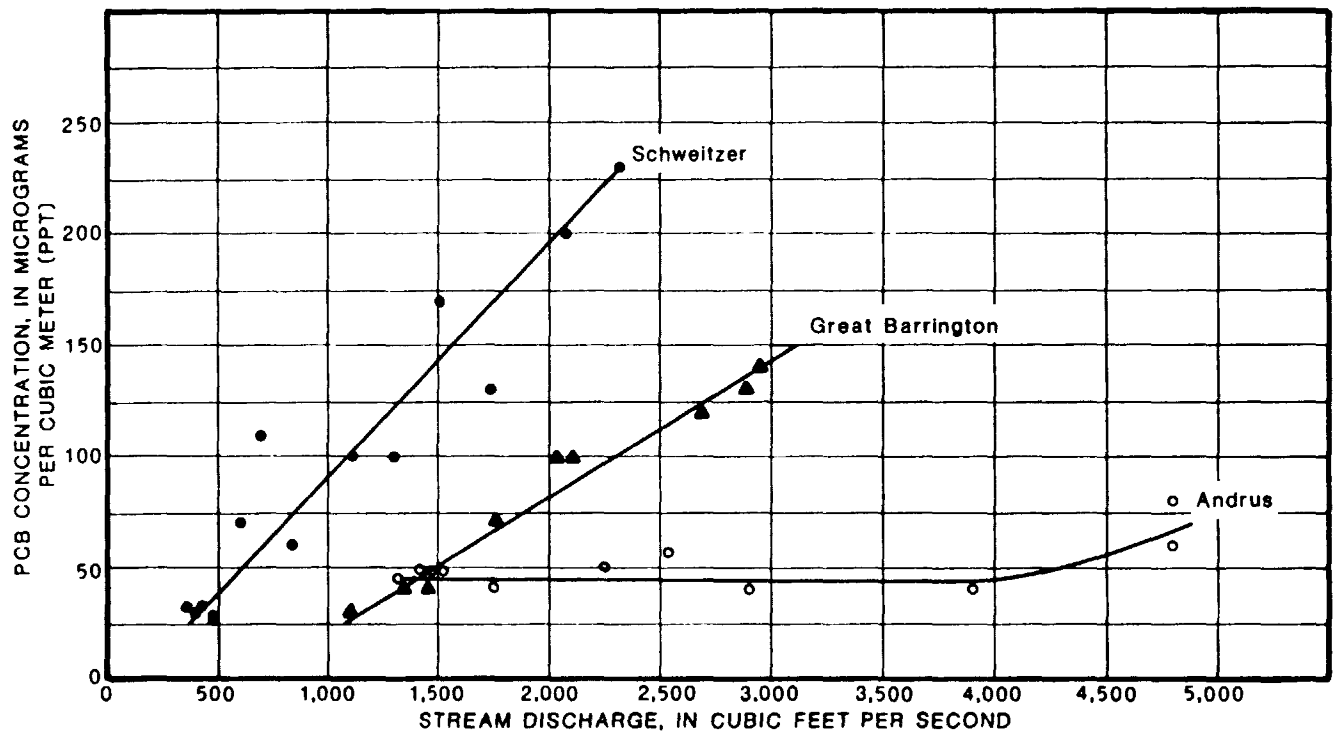


Figure 4-16

Total PCB Concentration of Water-Sediment Mixture Versus Flow

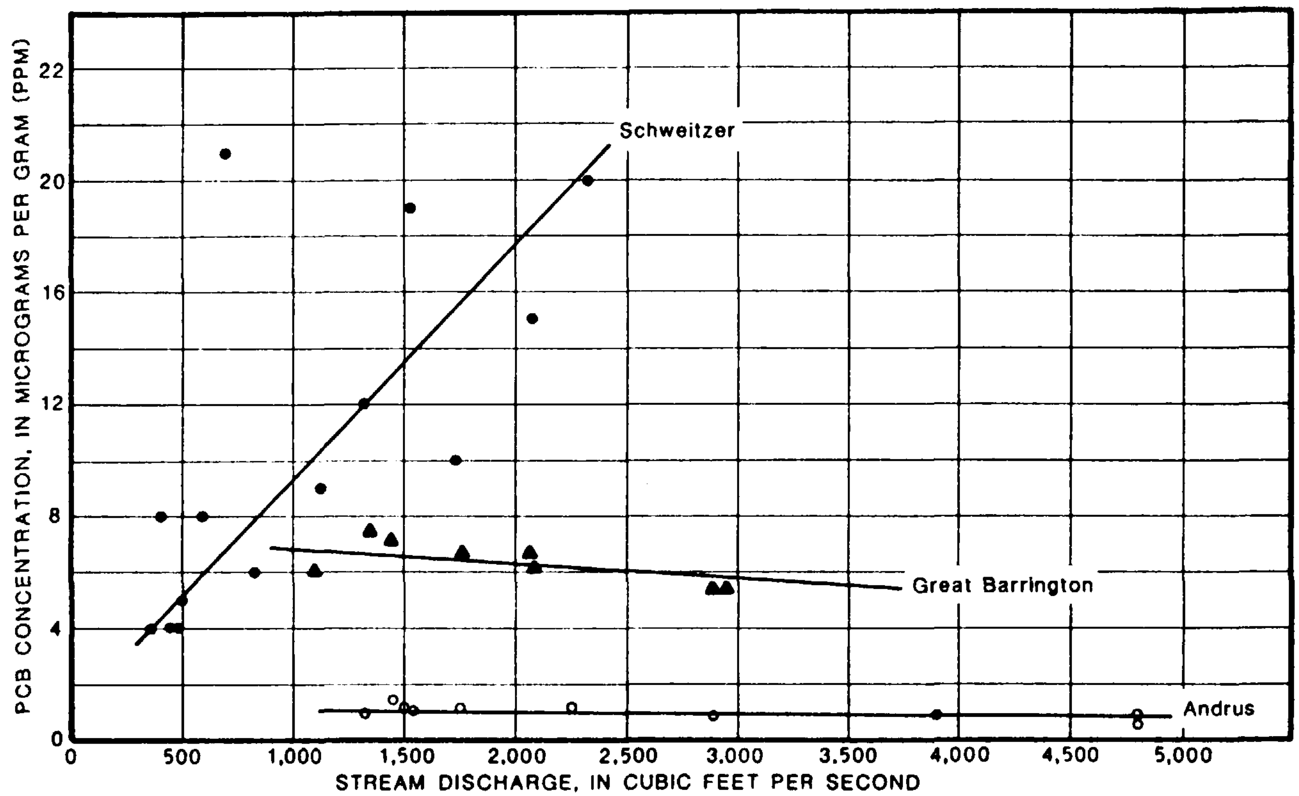


Figure 4-17

Total PCB Concentration of Suspended Sediment Versus Flow

increases in a downstream direction. This investigation has shown, however, that the rate of suspended-solids transport is nonuniform and varies considerably with changing stream discharge.

A comparison of instantaneous suspended-solids transport rates for the three stations follows:

(1) for flows of ~300 ft^3/sec

Schweitzer Bridge = 2 tons per day
Great Barrington = 7 tons per day
Andrus Road Bridge = 50 tons per day

(2) for flows of ~2,900 ft^3/sec

Schweitzer Bridge = 54 tons per day
Great Barrington = 1,500 tons per day
Andrus Road Bridge = 370 tons per day

4.5.3 Resuspension of Bottom Sediments Below Woods Pond Dam.

When one considers the fact that ninety percent of the PCBs in the sediments of the Housatonic River in Massachusetts are located above Woods Pond Dam, the initial inclination is to assume that the annual PCB discharge out of Woods Pond would control the quantity of PCBs moving past Great Barrington and Andrus Road Bridge. This, however, does not appear to be the case (Table 4-30). In fact, the projected yearly PCB discharge past Great Barrington, associated with nonfilterable suspended-solids, is 10 times greater than that passing the Schweitzer Bridge.

There are two explanations for this seemingly incompatible data. The first is that because of random and uncontrolled PCB transport out of Woods Pond through the Schweitzer by-pass canal, the amount of PCB passing the Schweitzer site is higher than the seven pound projection based only on statistical stream discharge. The second factor relates to the presence of PCB sediment repositories between the Schweitzer and Great Barrington transport sites and the influence of artificial channel controls on suspended-solids transport.

The presence of numerous dams and breached structures between the Schweitzer and Great Barrington transport sites has caused sediments containing PCBs to accumulate in the impounded stretches of the river. Each impoundment serves as a small repository where sediments may be deposited during times of quiet flow. Resuspension and transport further downstream can occur during high runoff events and periods of turbulent high flows.

An inventory of channel deposits in the summer of 1980 revealed that extensive quantities of bottom sediment exist in the impoundments behind the dams between the Schweitzer and Great Barrington sites. A graphic illustration of the estimated pounds of PCBs present in each sediment sampling station between Woods Pond Dam and the Connecticut state line is found in Figure 4-18. The estimated pounds of PCB contained in the bottom sediments between the Schweitzer Bridge and the Great Barrington site appear to be the primary source of PCBs moving past Great Barrington.

It was beyond the scope of the initial transport investigation to determine the magnitude of flow rates and other conditions under which these materials in this reach of river will resuspend and wash further downstream. However, it is likely that water velocity, regardless of how distant the precipitation may have been, is the principle factor influencing resuspension of bottom sediments between Schweitzer and Great Barrington.

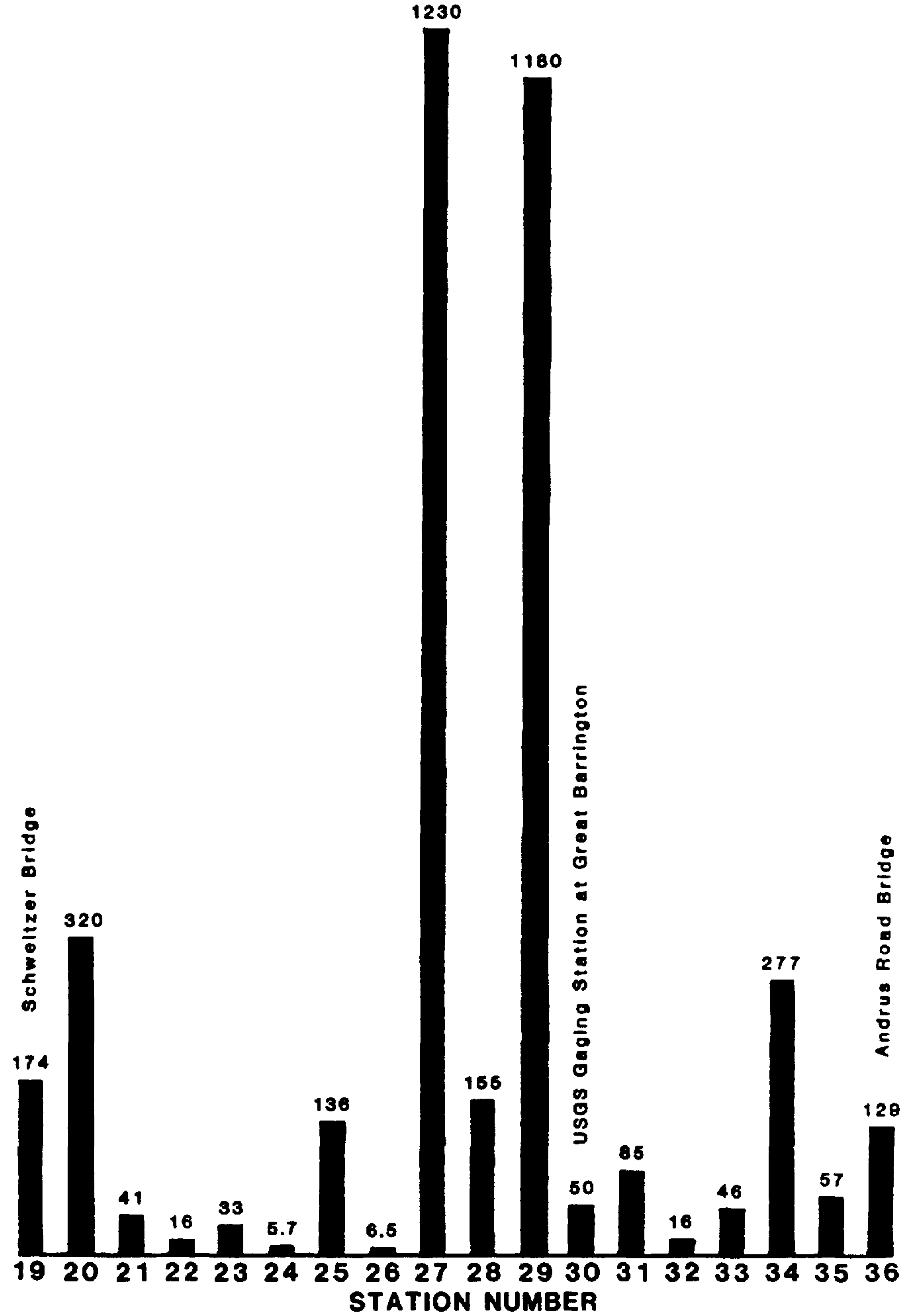


Figure 4-18

PCB LOAD (POUNDS) BY SEDIMENT STATION

Stations Between Woods Pond and Connecticut State Line

From Great Barrington downstream to Andrus Road bridge, the suspended-solids yield per square mile increases from 42 to 88 tons/year/mi^2. Generally, channel controls are insignificant in this segment of the river; and fine sediments are distributed homogeneously throughout the channel cross-section during times of rising water. Within the limitations of this study, it is not possible to estimate the relative proportion of fine sediments in the channel due to resuspension of materials upstream from Great Barrington and those due to local inflow. Nevertheless, because of the greater availability of soil particles resulting from the topography and agricultural activities in the area, it is apparent that adjacent lands provide a larger source of "local" sediments to this segment of the river than would be likely for the segment between Schweitzer and Great Barrington.

The channel gradient between Great Barrington and Andrus Road bridge is about two feet per mile. Consequently, the river is characterized by meanders and numerous oxbows; and sediment deposition is pronounced. The annual PCB discharge of 33 pounds for the Andrus Road site indicates a settling out and redeposition of some of the PCB-contaminated suspended-sediment passing Great Barrington with subsequent "silting over" and dilution by the influx of "local" sediments as discussed in the preceding paragraphs.

4.5.4 PCB Transport Past Schweitzer Bridge.

The relatively small annual PCB discharge rate computed (7 pounds) and the actual PCB discharge observed (5 pounds) during the high water event of the year (April storm) for the Schweitzer Bridge site, suggests that the Woods Pond area is fairly well stabilized. This indicates that most of the contaminated sediments below Woods Pond Dam were deposited previously, perhaps several years ago. Now that active transport from the primary deposition sites above Woods Pond dam is significantly reduced, the process of "silting over" and diluting the contaminated sediments with "local" uncontaminated sediments should result in a continual descrease in the quantity of PCB in transit throughout the Upper Housatonic River Basin.

4.6 Summary and Conclusions

4.6.1 Summary.

There are three transport modes involved in movement of PCBs in the Housatonic River. Specifically, PCB transport accompanies the movement of the following vehicles:

(1) PCB-laden, nonfilterable suspended sediments resuspended from bottom deposits,

(2) discrete, non-sediment, PCB-contaminated materials, and

(3) filterable PCBs in the water column.

One or more of these modes may occur simultaneously; however, the major mode of PCB transport is that associated with the deposition, resuspension, and redeposition of fine-grained particles containing sorbed PCB.

4.6.2 Conclusions.

Based on the experimental data derived from these investigations the following conclusions are drawn:

(1) At discharge rates up to 350 ft^3/sec for the Housatonic River at the Schweitzer Bridge, PCBs are transported by the movement

of discrete, non-sediment materials out of the Woods Pond area. This transport mode predominates for 75% of the flow duration. Transport by means of bottom sediment resuspension occurs at flows greater than 350 ft^3/sec. Although transport by means of bottom sediment resuspension is effective for only 25% of the streamflow duration, the largest mass of PCB movement occurs by this mode.

Movement of PCBs in the filterable fraction of the water column is superimposed upon sediment resuspension transport for the upper 12% of the streamflow duration. Transport of PCBs out of Woods Pond is influenced, in an unpredictable yet significant way, by the random operation of the by-pass sluice gates during periods of streamflow less than 700 ft^3/sec, or for ~90% of the streamflow duration.

(2) The major PCB transport mechanism observed at the Division Street bridge near Great Barrington is associated with bottom sediment resuspension. Transport by this mode is projected to occur at flows greater than 800 ft^3/sec, which represents a flow duration of 20 percent. Filterable PCB transport occurs simultaneously with sediment resuspension transport at flows greater than 1,750 ft^3/sec, or a streamflow duration of 4 percent. No detectable PCB movement is anticipated at the Great Barrington site 80% of the time.

(3) The overwhelming transport mechanism observed at the Andrus Road bridge site was nonfilterable PCB movement associated with the resuspension of bottom sediments. This mode is in effect with stream discharges greater than 1,300 ft^3/sec, which represents a streamflow duration of twenty percent. Transport by means of filterable PCBs in the water column occurs only for a streamflow duration of one percent of the time and is associated with flows in excess of 4,000 ft^3/sec. For 80% of the time, no detectable PCB transport is projected to occur at this site.

(4) Maximum PCB transport at all three sites occurred during a period of high flow associated with a storm event.

(5) PCB transport past Great Barrington and Andrus Road bridge is discontinuous and erratic and is associated primarily with high streamflow events.

6) The primary source of nonfilterable PCB between the Schweitzer and Great Barrington sites is the bottom sediments of the impounded reaches of the river.

(7) The Woods Pond area is not the sole source for all nonfilterable PCBs transported in the Housatonic River in Massachusetts.

(8) PCB transport past the Schweitzer Bridge can be increased significantly by opening the gates of the Woods Pond Dam by-pass canal. Sluice gate operation presently occurs on a random, uncontrolled basis.

SECTION FIVE

MASSACHUSETTS FISH STUDIES

5.1 General

During the 1980 fish collections, the objective was to collect only the four principle sport fish species indigenous to the Housatonic river study area -- namely, trout, bass, perch and sunfish. The 1982 collection objective was altered in keeping with the requirements of the Consent Decree to include fish, frogs and other aquatic life normally utilized for human consumption. As a consequence, the 1982 fish study was expanded to include the collection and analysis of chain pickerel, brown bullhead, crappie, and frogs and snapping turtles from the Woods Pond area. In addition, a concerted effort was made to collect eels in the Woods Pond area, but none were found.

The 70-mile study area was divided into eight (8) sampling stations (Figure 5-1). Their locations are as follows:

F1A - Headwaters of Center Pond in Dalton

F1B - Immediately below Center Pond Dam in Dalton to Bailey Road bridge in Pittsfield

F2 - Bailey Road Bridge to Headwaters of Woods Pond

F3 - Headwaters of Woods Pond to Woods Pond Dam

F4 - Woods Pond Dam to Columbia Mills Dam

F5 - Columbia Mills Dam to Highway 183 Bridge in Housatonic

F6 - Highway 183 Bridge in Housatonic to Rising Pond Dam

F7 - Rising Pond Dam to Massachusetts/Connecticut State line

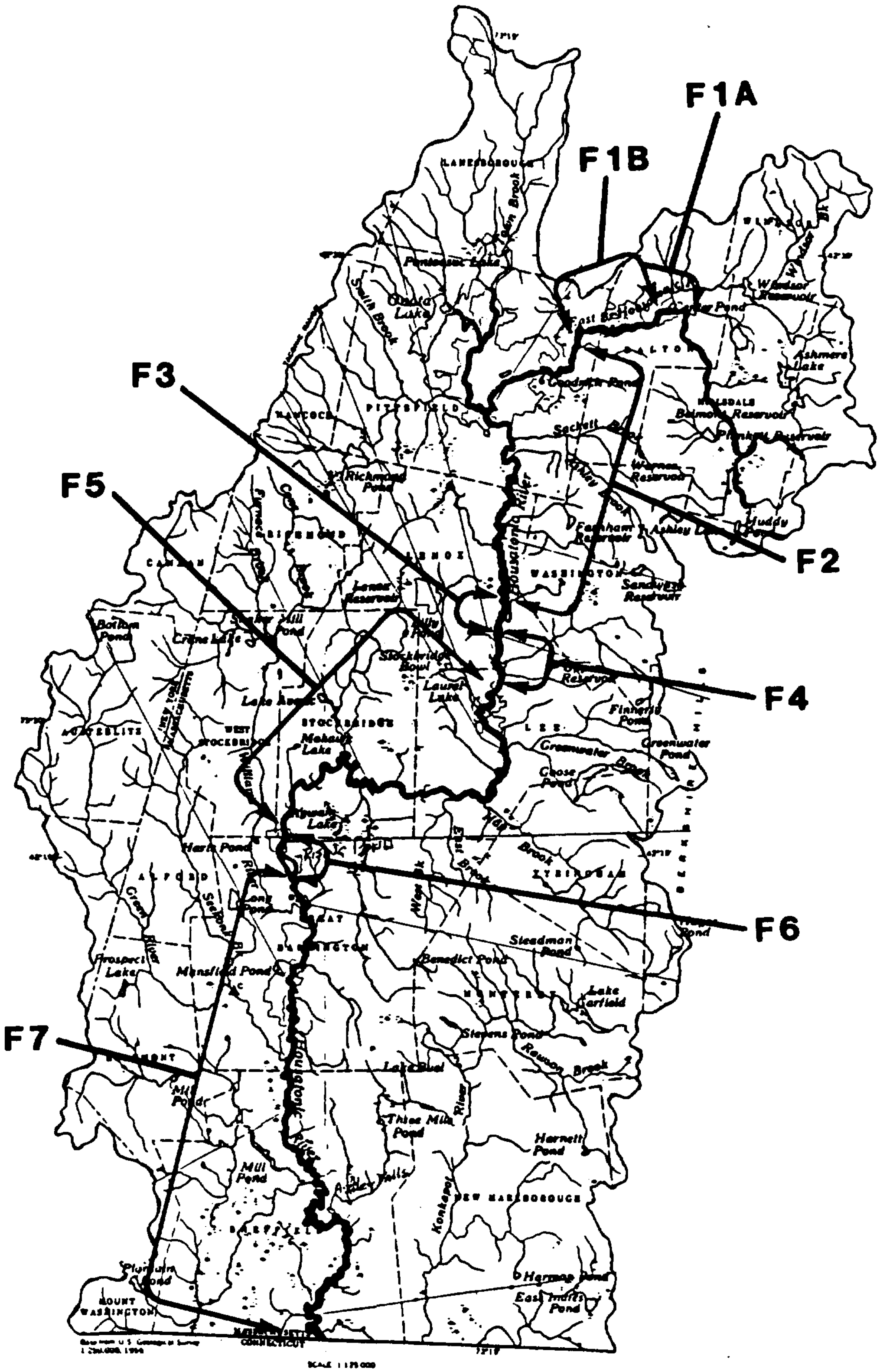


Figure 5-1

Housatonic River Fish Stations

5.2 Sampling Program Details

5.2.1 Fish Collection Techniques.

All fish collected in 1980 were taken by legal angling techniques; however, 1982 collections included both angling and gill netting allowed under a permit (SCFS1) issued by the Commonwealth of Massachusetts, Division of Fisheries and Wildlife. With the assistance of personnel from the Fisheries and Wildlife Division of the Massachusetts Department of Natural Resources, fish were collected on one occasion in 1982 by electroshocking with boat mounted probes in two study areas, namely Woods Pond and the New Lenox Road area. The combination of collection modes used in 1982 allowed a more complete and representative sampling in the various reaches of the river. Sample handling and quality control protocols are contained in Appendix 5-1.

5.2.2 Fish Population Densities.

Observations concerning densities of fish populations in the Housatonic River in Massachusetts were made based on the angling and gill netting results for the 1980 and 1982 collections. In general, fish angling for species normally utilized for human consumption is not very productive. Findings have shown that the heaviest population density occurs below dams and at the confluence of major streams entering the Housatonic River. Trout are particularly sparse; and although they are found on occasion in conjunction with other fish species, they are by no means abundant. On a comparative basis, the relative abundance of fish encountered in the eight (8) fish stations of the Housatonic River is shown in Table 5-1.

Table 5-1. HOUSATONIC RIVER FISH POPULATION OBSERVATIONS (1980-1982)

TYPE	STATION F1A/F1B	STATION F2	STATION F3	STATION F4	STATION F5	STATION F6	STATION F7
BASS	25%	2%	7%	2%	2%	14%	6%
TROUT	3%	1%	1%	*	1%	*	2%
PERCH	20%	15%	10%	30%	25%	50%	40%
SUNFISH	6%	10%	15%	40%	55%	20%	30%
PICKEREL	*	4%	4%	*	*	*	*
BULLHEAD	*	2%	2%	*	*	*	*
CRAPPIE	*	1%	2%	1%	*	*	2%
SHINERS	15%	20%	20%	*	*	*	*
SUCKERS	30%	40%	20%	20%	12%	10%	10%
GOLDFISH	1%	5%	19%	7%	5%	6%	5%
CARP	*	*	*	*	*	*	5%
OBSERVED:	100%	100%	100%	100%	100%	100%	100%

*NO SPECIES OF THIS TYPE OBSERVED

In summary, efforts to collect representative samples of fish normally utilized for human consumption for each fish station proved to be arduous and time consuming because much of the river areas do not provide proper habitat. Low-water levels, tributary influxes, and winter freezes contribute to the uneven distribution of fish in many stretches of the river. It would be highly impropable that a typical angler could duplicate the numbers and sites of fish represented by this study.

5.2.3 Collection Summary.

A total of 721 individual fish normally utilized for human consumption were collected during the two collection periods. The actual numbers and species collected at the various stations are contained in Table 5-2. Approximately 53% of the total collected were composited as appropriate and analyzed for PCBs. The remaining fish were archived for future use, if needed. For compositing purposes, the principle sport fish species collected were classified into four groups:

(1) perch - yellow perch
(2) sunfish - bluegill, green sunfish, pumkinseed
(3) bass - largemouth, rock
(4) trout - brown, rainbow, brook

In addition to the fish reported in Table 5-2, four species not normally utilized for human consumption were collected but not analyzed. These were shiners and suckers, from Woods Pond.

For the most part, the 1982 fish collections produced on the average larger specimens than those taken by angling in 1980. Because gill netting provides

Table 5-2 SUMMARY

MASSACHUSETTS FISH COLLECTIONS AND ANALYSIS COMPOSITES

FISH TYPE	STA F1A 1980	STA F1A 1982	STA F1B 1980	STA F1B 1982	STA F2 1980	STA F2 1982	STA F3 1980	STA F3 1982	STA F4 1980	STA F4 1982	STA F5 1980	STA F5 1982	STA F6 1980	STA F6 1982	STA F7 1980	STA F7 1982	TOTALS
YELLOW PERCH																	
Analyzed	7	-	12	-	10	12	12	12	12	-	12	-	12	-	12	-	113
Archived	-	12	1	-	-	20	1	29	3	-	2	-	4	-	16	-	88
SUNFISH																	
Analyzed	-	-	4	12	-	12	12	12	12	-	12	-	12	-	12	-	100
Archived	-	5	-	4	1	9	3	27	5	1	34	13	8	7	19	-	136
BASS																	
Analyzed	-	-	12	-	-	12	-	10/12	-	12	1*	4*	2	10	12	1	88
Archived	-	1	12	43	-	2	-	13	-	-	-	-	-	-	-	-	71
TROUT																	
Analyzed	3	6	-	3	-	1/1/1	-	4	-	-	-	3	-	-	-	3	25
Archived	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHAIN PICKEREL																	
Analyzed	-	-	-	-	-	12	-	12	-	-	-	-	-	-	-	-	24
Archived	-	-	-	-	-	16	-	6	-	-	-	-	-	-	-	-	22
CRAPPIE																	
Analyzed	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	8
Archived	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	3
BROWN BULLHEAD																	
Analyzed	-	-	-	-	-	12	-	12	-	-	-	-	-	-	-	-	24
Archived	-	-	-	-	-	13	-	5	-	-	-	-	-	-	-	-	18
MUSKELLUNGE																	
Analyzed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Archived	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
																TOTAL	721

ANALYZED: 382
ARCHIVED: 339

*Composited 1980-82 fish for analysis

for sampling on a 24-hour basis, the majority of the fish moving past a given river location were netted. As the nets were checked approximately every four hours, the larger fish were selectively retained for collection purposes. Although the specimens included in each composite were selected to represent the complete size range of the collection, the overall fish size was larger in 1982 as compared to 1980.

Field and preparation data for both analyzed and archived fish are appended. Data relating to fish composites which were analyzed in 1980 and 1982 are contained in Appendix 5-2 and 5-3, respectively. Pertinent information relative to 1980 and 1982 archived fish are found in Appendices 5-4 and 5-5.

5.3 PCB Levels in Fish, Frogs and Other Aquatic Life

As required by the Consent Order, 18 fish composites from the 1980 collections and 20 composites plus threeindividual fish from the 1982 collections were prepared and analyzed for PCB content. The sample preparation protocol is given in Appendix 5-6. Frog and turtle composites from the 1982 collection were also analyzed. Complete analytical data for both the 1980 and 1982 collections are contained in Appendix 5-7.

5.3.1 PCB Levels in Fish.

A summary of PCB levels in the four major fish classifications normally utilized for human consumption is found in Table 5-3. As was noted earlier in Section 5.2.3, the fish collected in 1982 were, on the average, larger than those taken in 1980. The correlation between PCB levels and fish size is apparent when one compares the 1980 and 1982 data for the same fish species from the same location. This correlation is also shown in Table 5-4.

Table 5-3. Summary - PCB Levels in Fish

Station	Collected	Sunfish	Perch	Bass	Trout	Avg. PCB in Sediment of Related River Stations (ppm)
1A	1980	-	0.06	-	0.04	Below Detection
	1982	-	-	-	0.31	
1B	1980	0.67	1.7	1.6	-	0.02
	1982	2.7	-	-	135.	
2	1980	-	3.3	-	-	41.
	1982	2.2	5.6	4.2	153.	
3	1980	4.2	3.0	-	-	24.
	1982	4.7	6.1† 5.7†	20.†† 8.1††	119.	
4	1980	3.0	3.3	-	-	5.5
	1982	-	-	20.	-	
5	1980	2.9	1.1	-	-	2.3
	1982	-	-	11.	11.	
6	1980	2.6	3.9	7.4	-	4.7
	1982	-	-	7.2	-	
7	1980	2.7	3.0	3.9	-	0.66
	1982	-	-	6.9	3.3	

† Two 12-fish composites were analyzed.

†† Two composites, one largemouth and one rock bass were analyzed.

Table 5-4. Relationship of PCB Content to Fish Size and Species

Sample No.	Description	Weight (g)	Length (mm)	% Lipids	Conc. PCB µg/gm Wet Tissue
6485	Brown Trout	907.	420.	5.55	240.
7071	Brown Trout	662.	380.	7.71	192.
6486	Rainbow Trout	326.	320.	1.53	27.

PCB concentrations in fish vary with the species due to differences in food gathering habits, behavior patterns, and body fat content. Metabolic rate and body size affect uptake rates as well as elimination.

A tabulation of PCB levels in fish (Stations 2 and 3) taken from the river locations constituting the primary PCB repository (Sediment Stations 9-18) is given in Table 5-5.

5.3.2 Comparison of PCB Levels in Fish and Sediments.

Adsorption of PCB residues on the organic fraction of suspended solids leads to the incorporation of these particles into the sediments of aquatic systems. In addition, aquatic organisms which may serve as food items for the associated fish species may accumulate PCBs from the contaminated sediments. Continued predation of these organisms may lead to further accumulation of PCBs in the fish. For this reason, it is important to evaluate the relation between PCB levels in the fish and the sediment of their habitat.

Based on the data from Tables 5-3 and 5-5, the general statement can be made that the highest levels of PCB found in fish correspond to areas where PCB loads

Table 5-5. Fish Data From Area of Maximum Sediment PCB Content

Classification	PCB Concentration, µg/gm (ppm) Wet Tissue Station 2 Upstream of W.P.	Station 3 Woods Pond
Perch (1980)	3.3	3.0
Perch (1982)	5.6	6.1, 5.7
Sunfish (1980)	-	4.2
Sunfish (1982)	2.2	4.7
Bass†† (1982)	4.2	-
Rock Bass (1982)	-	8.1
L.M. Bass (1982)	-	20.
Trout (1982)	153.†	119.
C. Pickerel (1982)	3.7	13.
B. Bullhead (1982)	12.	11.
Crappie (1982)	-	12.

† The three trout of this composite were analyzed as individual samples. See Table 5.3 for individual data.

†† This composite contains both Largemouth and Rock Bass.

are highest in sediments. It can also be said that for certain fish species (especially trout), PCB levels in the fish follow closely the PCB concentrations of the sediment as one continues down the river. There are other species, however, which have a relatively constant, low concentration of PCBs in their tissue regardless of their river habitat. Sunfish and perch exhibit this behavior (see Figure 5-2). The correlation between the PCB content of bass and the PCB content of the related sediment is not clear. Data scatter is probably due to the added impact of fish size and the carnivorous eating habits of the bass upon PCB accumulation. A log-log plot of the PCB content of sediment against the PCB content of bass and trout is shown in Figure 5-3.

5.3.3 PCB Levels in Frogs and Other Aquatic Life.

5.3.3.1 PCB Levels in Plants. The vegetation examined was comprised of specimens from 12 genera. All samples were collected in 1980 from areas along the entire river. All sediment samples collected in association with plants were analyzed. Selected plants from various river mile sites were also analyzed for PCBs based on corresponding sediment data. Results of the analyses (Table 5-6) indicated that even in sediments with total PCB concentrations as high as 151 ppm, the associated vegetation (water milfoil and lesser duckweed) had PCB levels of 3.91 ppm. This latter value was the highest level found in any vegetation taken from the entire river study area. It was collected at river mile 43.59 in Woods Pond. Based on this study, it was felt that total PCB concentrations in vegetation was not at levels significantly high enough to warrant additional sampling. The following lists the common and scientific names for plant identifications:

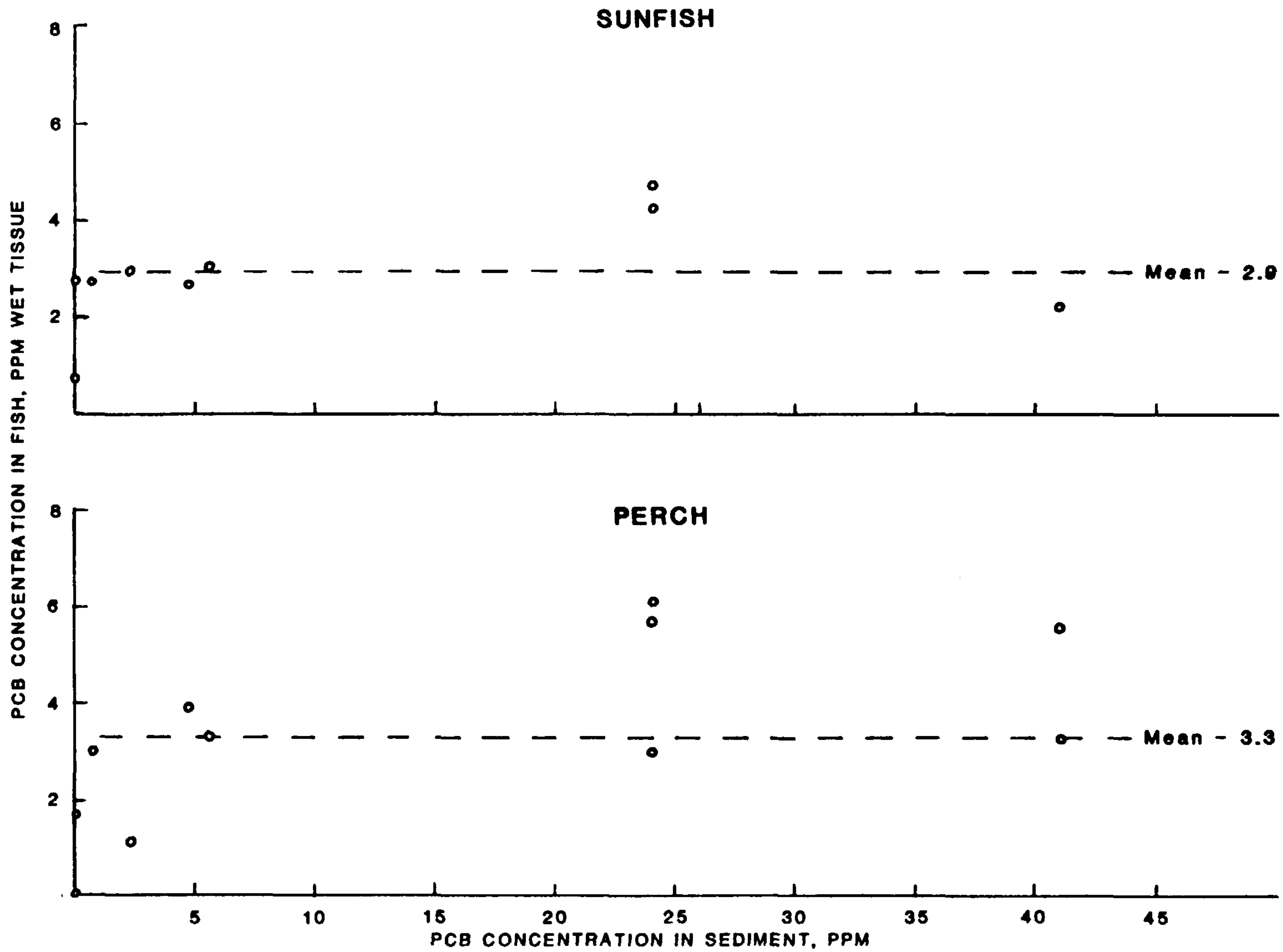


Figure 5-2

Correlation of PCB Levels in Fish and Sediment

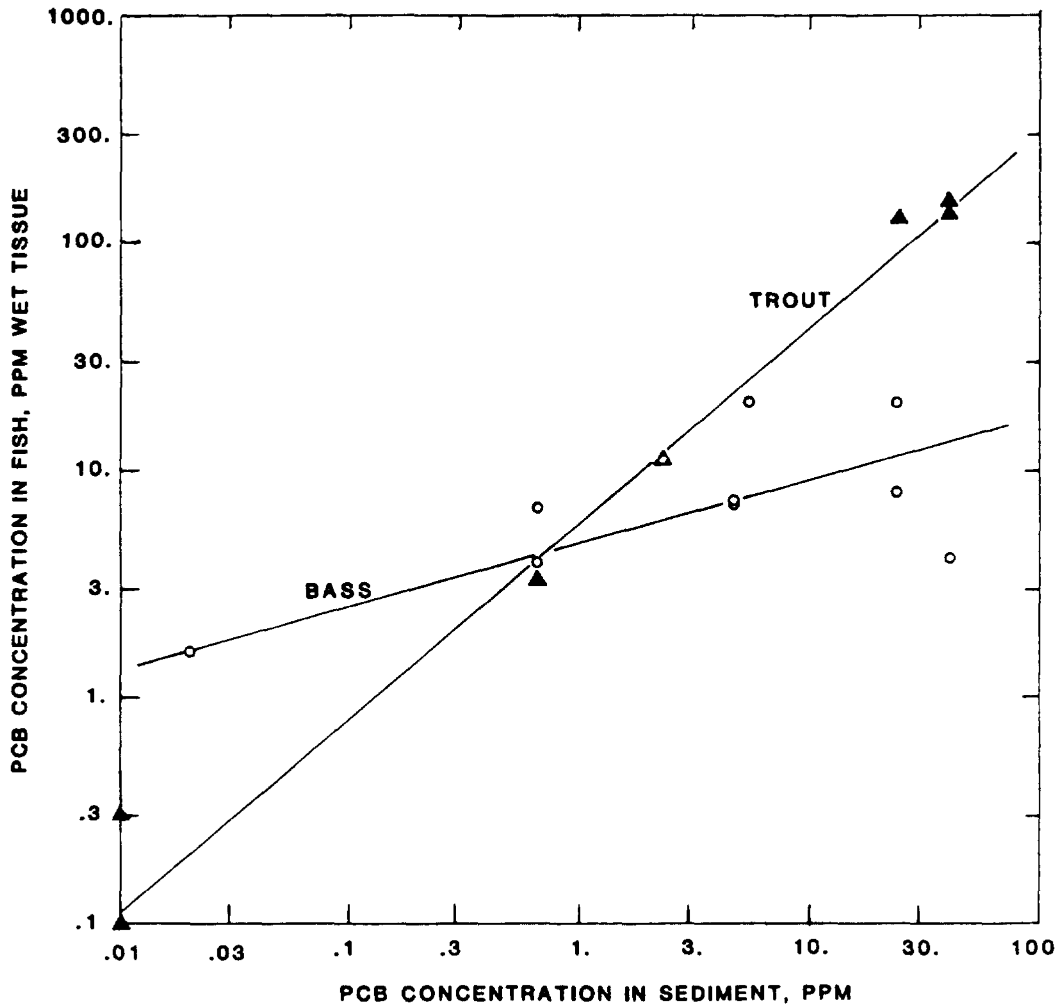


Figure 5-3

Correlation of PCB Levels in Fish and Sediment

Table 5-6. Plant/Sediment Data

River Mile	Date	Collection Site	Sample Identification*	Concentration (µg/gm dry basin) Aroclor 1254	Aroclor 1260
3.57	7/3/80	S35C	3310 Duck Potato	0.10	0.12
			3313 Sediment	0.08	0.24
27.27	7/5/80	S28	3393 Duck Potato	0.04	0.16
			3388 Sediment	0.43	1.7
36.71	7/6/80	S24A	3427 Duck Potato	0.09	0.33
			3424 Sediment	0.05	0.49
43.63	8/24/80	S18F1	5609 Milfoil & Duckweed	0.72	1.6
			5447 Sediment	ND	190.
43.62	8/24/80	S18D2	5603 Milfoil & Duckweed	1.0	2.5
			5521 Sediment	7.8	31.
43.61	8/24/80	S18E2	5605 Milfoil & Duckweed	0.58	1.6
			5571 Sediment	ND	7.3
43.61	8/24/80	S18K3	5611 Milfoil & Duckweed	0.46	0.93
			5437 Sediment	12.	82.
43.59	8/24/80	S18J2	5657 Milfoil & Duckweed	0.91	3.0
			5527 Sediment	31.	120.
43.57	8/24/80	S18K1	5655 Milfoil & Duckweed	0.35	0.58
			5429 Sediment	ND	130.
43.53	8/24/80	S18L2	5654 Milfoil & Duckweed	0.49	1.3
			5426 Sediment	0.65	9.0
43.48	8/24/80	S18M2	5642 Milfoil & Duckweed	0.59	1.4
			5362 Sediment	7.2	52.
43.39	8/24/80	S18C2	5630 Milfoil & Duckweed	0.45	1.2
			5393 Sediment	1.1	4.7
43.35	8/24/80	S18A1	5631 Milfoil & Duckweed	0.66	2.4
			5389 Sediment	21.	130.
47.08	7/7/80	S17A12	3474 Duck Potato	0.20	0.64
			3470 Sediment	1.6	5.4
59.54	7/8/80	S3A	3524 Duck Potato	ND	ND
			3524 Sediment	ND	ND

ND = None detected.

Common Name	Scientific Name
Duck Potato	*Sagittaria latifolia*
Crisp Pondweed	*Potamogton crispus*
Hornwort	*Ceratophyllum demersum*
Cattail	*Typha latifolia*
Yellow Water Lily	*Nuphar advena*
Western Bur-reed	*Sparganium multipedunculatum*
Pickerelweed	*Pontederia cordata*
Water Milfoil	*Myriophyllum heterophyllum*
Arrow Arum	*Peltandra virginica*
Lesser Duckweed	*Lemna minor*
Rush	*Juncus* sp.
Water Weed	*Limnobium* sp.

5.3.3.2 PCB Levels in Frogs and Snapping Turtle. Bullfrogs and a snapping turtle were collected from Woods Pond in 1982. There does not appear to be a correlation between the high PCB levels of Woods Pond sediments and the concentration of PCBs in these specimens. Analytical data for these animals are contained in Table 5-7.

Table 5-7. PCB Levels in Woods Pond Frogs and Turtles

Type of Animal	Composite Number	No. in Composite	% Lipids	Concentration (μg/g wet tissue) Aroclor 1254	Aroclor 1260	Total PCB
Frogs	6483	12	0.23	ND	4.4	4.4
Turtle	6484	1	0.18	ND	2.1	2.1

5.4 Condition of Fish in the Housatonic River in Massachusetts

As a rational means of comparing the overall condition of fish in one location with similar species in another location, an evaluation involving the lengths and weights is used to determine the relative robustness of fish (condition). Lengths in centimeters and weights in grams are used for calculating condition factors (C) using the formula from Ricker (1975) where

$$C = \frac{10^2 W\ (gm)}{L^3\ (cm)}$$

A total of 721 fish from both the 1980 and 1982 collections were evaluated.

Several observations can be made from the data presented in Tables 5-8 and 5-9.

(1) Condition of largemouth bass and bluegill compares favorably to published mean values for selected U.S. populations. According to standards from Minnesota (Carlander, 1944) and Illinois (Bennett, 1948), bluegill are in good to excellent condition:

MN	poor	1.66
	average	1.83 - 2.24
	excellent	2.52
IL	poor	1.39
	average	1.39 - 2.22
	excellent	2.22

When compared to Illinois standards, largemouth bass generally fall in the good category:

IL	poor	0.97 - 1.25
	average	1.26 - 1.52
	excellent	1.53 - 1.80

In both largemouth bass and bluegill, condition is generally highest in late spring and early summer with a decrease in late summer and fall.

Table 5-8. Condition--All Fish
September--October 1980

STATION

Species	F1A	F1B	F2	F3	F4	F5	F6	F7
				ANALYZED				
RbwTrt	(1.00)							
BrnTrt	1.04							
BrkTrt								
YwPrch	1.14	1.15	1.22	1.29	1.50	1.49	1.37	1.56
BG				2.26	2.17	2.53	2.20	2.51
GrSunf								
RckBss		2.06						2.36
LMB							1.73	1.50
BlCrap								
Musky								
ChPick								
BlBull								
PmpkSd								(2.63)
RedEar		2.08			(1.97)			
				ARCHIVED				
RbwTrt								
BrnTrt								
BrkTrt								
YwPrch		(1.05)		(0.68)	1.34	1.39	1.23	1.32
BG			(1.97)	2.23	(2.01)	2.25*	2.29*	2.43*
GrSunf								
RckBss		1.91						
LMB						1.77*		
BlCrap								2.23
Musky								
ChPick								
BlBull								
PmpkSd								2.50*
RedEar					2.28			(2.27)*

( ) denotes a single specimen
* over half of specimens collected in July, 1980

Table 5-9. Condition--All Fish
1982: June--August

STATION

Species	F1A	F1B	F2	F3	F4	F5	F6	F7
				ANALYZED				
RbwTrt	1.07		(0.99)	(1.06)				
BrnTrt	1.24	1.22	(1.22)	1.32		(1.54)		1.13
BrkTrt		(1.02)						
YwPrch			1.24	1.53				
BG		1.91	2.36	2.19				
GrSunf		2.15	2.30	(2.73)				
RckBss			2.20	2.43	2.20	2.36	2.39	
LMB			1.75	1.66	1.60	1.76	1.76	(1.59)
BlCrap				1.97				
Musky								
ChPick			0.75	0.72				
BlBull			1.35	1.96				
PmpkSd			2.19					
RedEar								
				ARCHIVED				
RbwTrt								
BrnTrt								
BrkTrt								
YwPrch	1.21		1.38	1.48				
BG			(2.14)	2.58	(2.48)	2.80	2.44	
GrSunf	2.18	2.02	2.76	2.67		(2.79)		
RckBss	(2.28)	2.04	2.11					
LMB				1.69				
BlCrap					(1.78)			
Musky			0.68					
ChPick			0.73	0.74				
BlBull			1.36	1.43				
PmpkSd			2.28	2.54				
RedEar								

( ) denotes a single specimen
* over half of specimens collected in May,1982

(2) Condition of brown trout compared favorably to that of records from several North American sources. One study from New York (NY State Hatcheries) recorded C values of approximately 1.06 - 1.45 (assuming approximate 10% conversion from standard length total length). Highs of condition factors were reported during spring and summer months with lows in winter and early spring. In fish less than 60 cm (600 mm), there is little difference in condition due to sex of fish (Carlander, 1969). Carlander (1969) also states that tagged trout have lower condition than untagged trout, resident trout have higher condition factors than stocked trout which have been in the river for a time, and stocked trout lose condition after stocking.

(3) Fish for the 1982 sampling appear to have overall higher condition factors than the same species collected in 1980. In particular, yellow perch, bluegill, brown trout, and possibly largemouth bass exhibit this trend (Figures 5-4 and 5-5). Possible explanations for this higher condition might be more favorable water quality, availability of food, and lower densities of fish.

When condition values (Figures 5-4 and 5-5) are related to PCB loads in the sediments in the Massachusetts portion of the Housatonic (see Table 5-3), there does not appear to be any significant correlation between them. However, there is a slight increase in condition of perch, sunfish, and brown trout as you move downstream from station F2. This generalization does not hold true for brown trout in station F7. The converse is apparent with largemouth bass as fish in station F2 show the best condition; however, the increase is not significantly higher than condition of fish at other stations.

In summary, all of the fish species in the Housatonic River in Massachusetts appear to be in good to excellent condition.

5.5 Summary and Conclusions

5.5.1 Summary.

The Massachusetts fish studies have established the PCB level in fish, frogs and other aquatic life normally utilized for human consumption. PCBs were detected in the fish from all stations; however, only background levels were found in the control station (Station 1A). Fish with the highest levels of PCB were found in

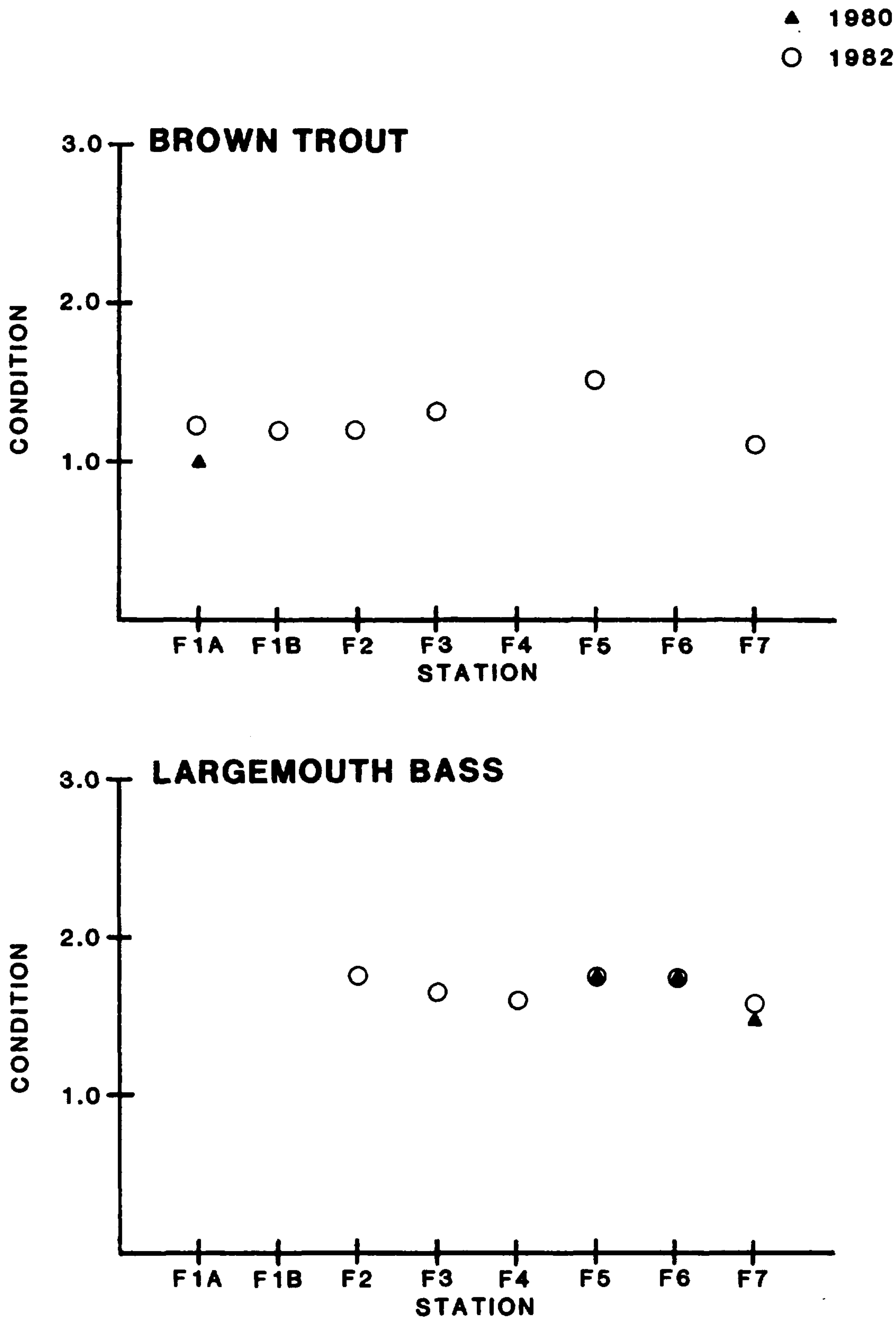


Figure 5-4

Comparison of Condition Factors--1980 and 1982 Fish

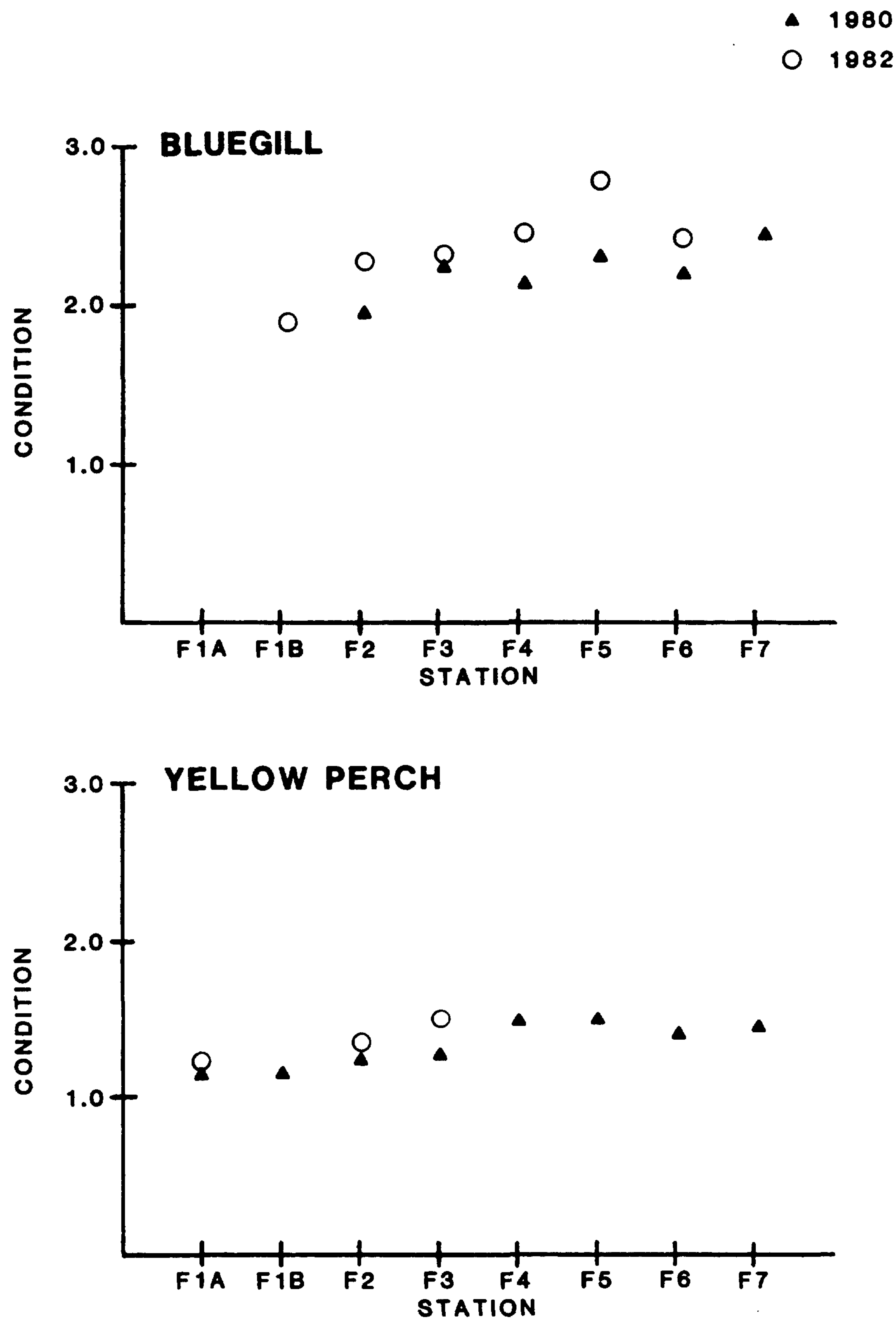


Figure 5-5

Comparison of Condition Factors--1980 and 1982 Fish

the reach of the river which contains approximately 90% of the sediment PCB load.

Although there are selected areas of high fish population densities, much of the Housatonic River in Massachusetts is not very productive for fish species normally utilized for human consumption. The condition of the four major game fish populations in the river (sunfish, perch, bass and trout) are rated as good to excellent.

The use of gill nets and electroshocking techniques, in addition to conventional angling, resulted in the collection of larger specimen for the 1982 study. Consequently, the PCB levels are somewhat higher than those found in the 1980 fish.

5.5.2 Conclusions.

Based on the results of this investigation, the following conclusions are drawn:

(1) Sunfish and perch have a relatively constant concentration of PCBs in their tissue regardless of their river habitat. The mean PCB concentration for all fish stations is 2.9 ±0.9 ppm for sunfish and 3.3 ±1.3 ppm for perch. Both of these levels are below the 5.0 ppm FDA limit for PCB levels in edible fish tissue.

(2) Trout are the most effective concentrators of PCB of all fish species examined. The PCB concentration in trout ranged from 3.3 to 240 ppm and was closely correlated with the PCB level of the sediment.

(3) All but one species of fish (sunfish) from Woods Pond have a PCB concentration greater than 5 ppm in the edible tissue.

(4) Fifty-seven percent of the fish species collected upstream of Woods Pond (Station 2) have PCB levels less than 5.0 ppm.

(5) Downstream of Woods Pond dam, seventy percent of the fish species have PCB levels below 5.0 ppm.

(6) PCBs have not accumulated to any significant degree in the aquatic vegetation of the Housatonic River.

(7) The PCB level of both frogs and a snapping turtle from Woods Pond is below 5.0 ppm, the FDA limit for human consumption.

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SECTION SIX

SILVER LAKE SEDIMENT INVESTIGATIONS

6.1 General

Silver Lake is located in Pittsfield, MA adjacent to the GE plant. It has a surface area of about 26 acres and is approximately 30 feet deep at its deepest point. The outlet from the lake is near the corner of Fenn and East Streets. Discharge from the lake enters a channel from which the water moves into the Housatonic River via a 48" diameter conduit.

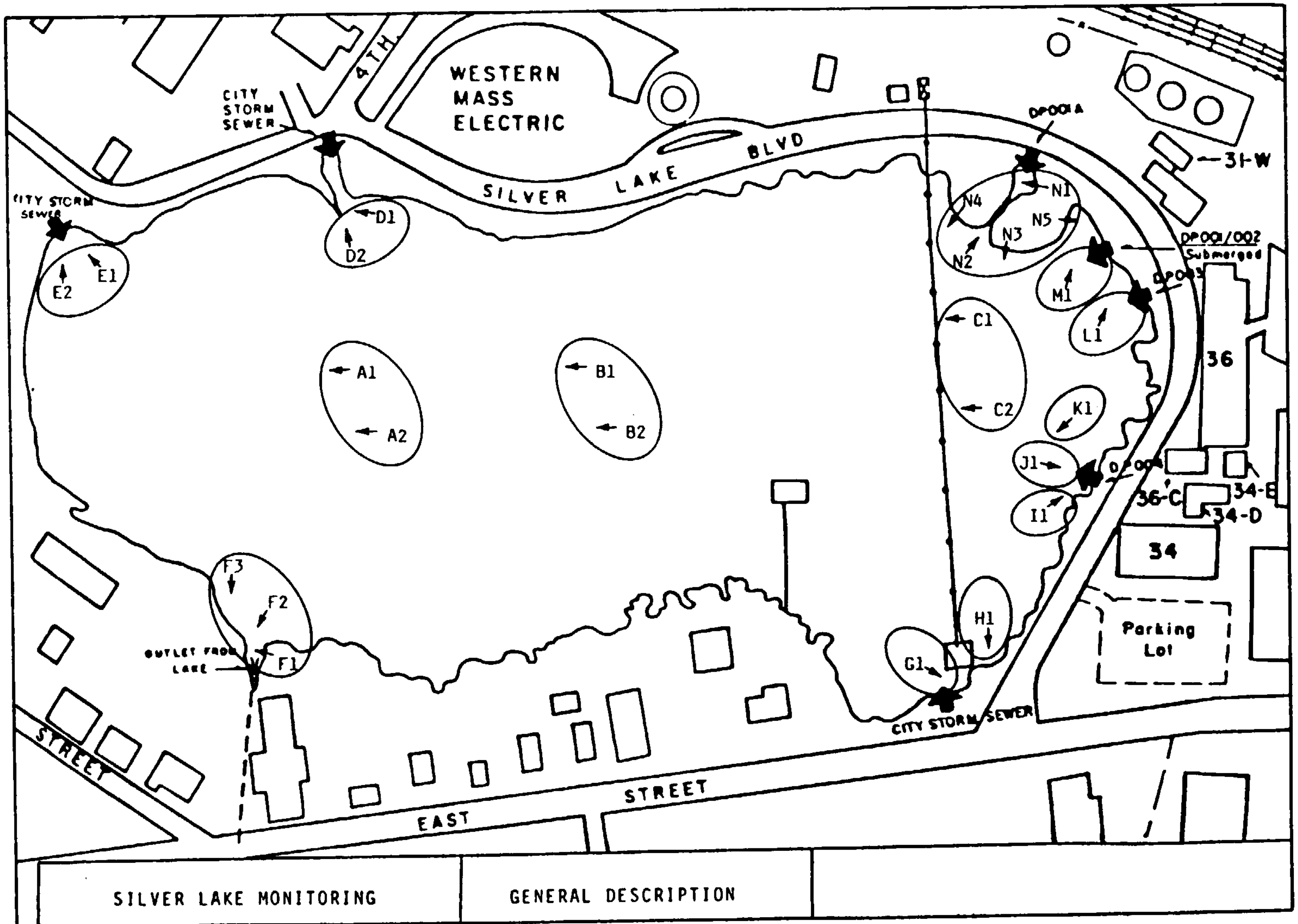
Sediment sampling in Silver Lake was conducted in October 1980 for deep water collections and June 1982 for peripheral samples. Peripheral sampling sites were located at all point discharges into the lake. Sampling locations are shown in Figure 6-1.

6.2 Sampling Program Description

The objective of these investigations was to define the locations and concentrations of PCBs within the sediment of Silver Lake. Sample handling and quality control protocols were the same as those employed in the Housatonic bottom sediment investigations (Appendix 3-3).

6.2.1 Deep Water Collections.

Bottom depositions in the region of Silver Lake where water depth ranged from 24 to 28 feet were sampled in 1980. Collections were achieved by anchoring a raft and two motor driven boats over each sampling point. Sections of pipe of varying lengths joined by quick-disconnect fittings were inserted into the



STATIONS A-C: Deep Water 1980 Collections
STATIONS D-N: Peripheral 1982 Collections

Lake Gage reading: 1.20

Figure 6-1
Silver Lake Sediment Sampling Points

sediment to a total depth of 40 feet from the top of the water. An adjustable length piston sampler was used to extract 16 cm portions of the sediment (when possible) from inside the pipe. A select number of samples from deeper deposition levels were taken with an adjustable length open bucket auger. Analytical results for preliminary composites of similar type sediments and discrete increment data are contained in Appendix 6-1 and 6-2, respectively.

6.2.2 Peripheral Sample Collections.

All collections were made with a piston sampler from inside a restraint pipe which extended above the water level. Samples were taken separately in 16 cm intervals down to refusal. Use of a boat was required for all sample collections. Field and analysis data are found in Appendix 6-3.

6.3 PCB Analysis Difficulties

It is significant to note that some of the sediment samples from Silver Lake exhibit several alterations in the characteristic patterns of Aroclor 1254 and 1260, while others give chromatograms which match completely the standard patterns for the PCBs. Three extracts of samples which showed representative pattern alterations were subjected to extensive "clean-up" procedures, and the extracts were reanalyzed. The pattern alterations were still present in all three extracts. These samples were then analyzed by GC/MS. All peaks in the chromatograms were reverse searched using the EPA/NBS standard reference library. All of the peaks in two of the samples were confirmed to be PCBs. The third sample contained polynuclear aromatic hydrocarbons in addition to PCBs.

In summary, all samples were confirmed as containing Aroclor 1254 and 1260. However, many di-, tri-, and tetrachlorobiphenyls were present which do not match the patterns of Aroclor 1242, 1248, and 1254. This situation presents an analysis problem which could not be addressed under the scope of the contract for the support of the Consent Order investigation. Before the samples exhibiting the alterations can be analyzed completely for total PCB content, it will be necessary to identify the individual PCB isomers present so that standards can be prepared for quantitation purposes. This will involve a significant amount of research and method development and is beyond the scope of the present Consent Order. It is, therefore, necessary to qualify the analytical results for both the 1980 and 1982 Silver Lake sediments as representing only that portion of the total PCBs in the sample which are present as unaltered Aroclor 1254 and 1260.

6.4 Distribution of PCBs in Silver Lake Sediment

The variation of PCB content and distribution in Silver Lake sediments is extreme. However, ninety-five percent of the total PCB load is located in the top two feet of the sediment. The area of highest PCB concentration is in the vacinity of discharge point 001A and includes the delta as well as the bottom sediments. The Aroclor pattern alteration is found in 40 of the 72 individual peripheral samples and all of the deep water samples. An illustration of PCB distribution in selected cores is shown in Figure 6-2.

6.4.1 PCB Levels in Deep Water Sediments.

The concentration of PCBs in the areas sampled ranged from 37 to 1002 ppm (see Table 6-1). The highest concentrations were found in sample C-1 which is located in the proximity of the GE plant outfalls. Although the sediment appears to be over twenty feet deep, PCB contamination is essentially all found

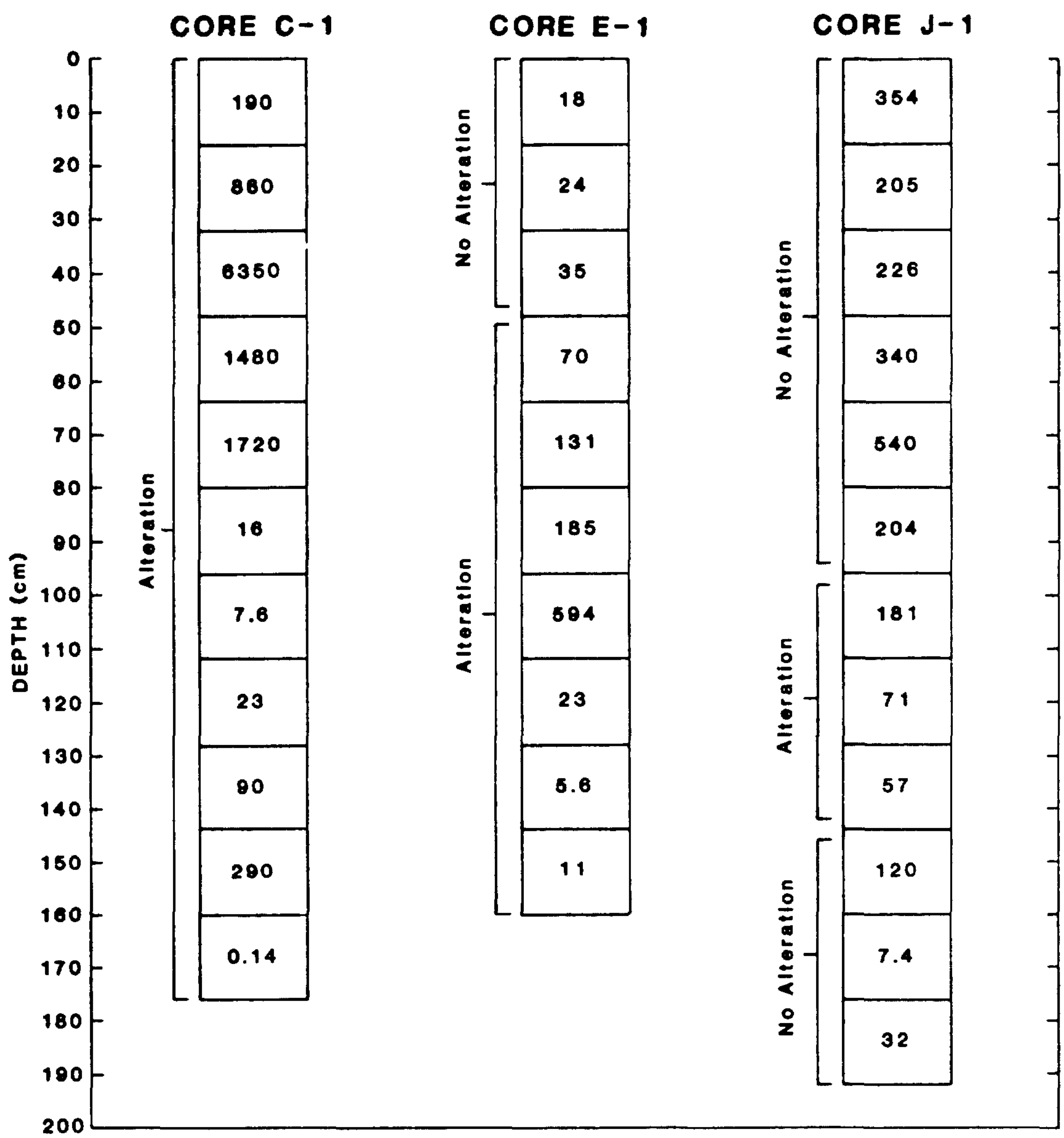


Figure 6-2

PCB Concentration (ppm) at Depth Intervals in Cores

in the top 2½ - 3 feet. The average PCB concentration for the bulk of the deep water sediments is about 150 ppm.

Table 6.1 Summary of Deep-Water PCB Distribution

Sample	Depth (cm)	Concentration PCB, ppm			Percent Aroclor		Pattern Alteration
		1254	1260	Total	1254	1260	
A1	80	27.	10.	37.	74.	26.	Yes
A2	80	159.	56.	215.	74.	26.	Yes
B1	80	224.	30.	254.	88.	12.	Yes
B2	80	32.	11.	41.	79.	21.	Yes
C1	176	912.	90.	1002.	91.	9.	Yes
C2	144	276.	45.	321.	86.	14.	Yes

6.4.2 PCB Levels in Peripheral Samples.

The data for the Silver Lake peripheral samples is contained in Table 6-2. Two distinct sediment classes were encountered, namely, black organic material overlying sand and silt (Stations E, F2, F3, G, H, I, J) and gravel with sand at the outfall areas (Stations D, K, L, M, N).

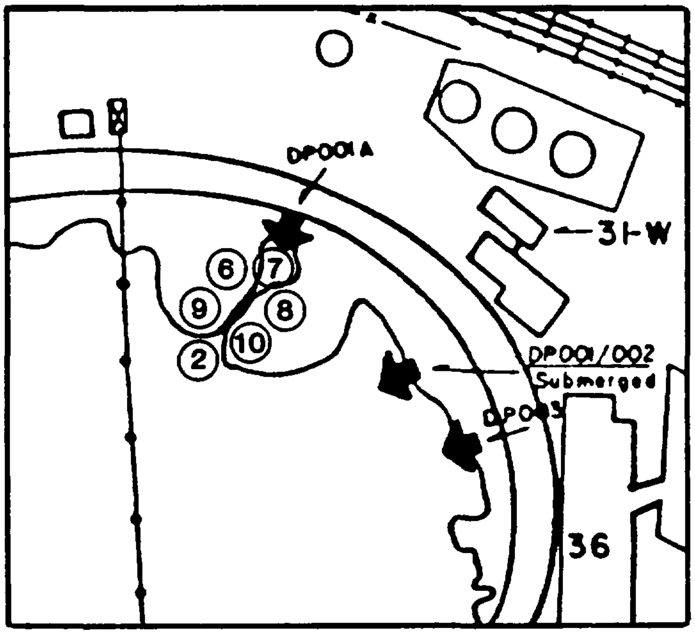
6.4.3 PCB Distribution at Discharge Point 001A.

The highest PCB concentrations found were associated with discharge point 001A. A special study conducted in May and June 1980 by GE and Stewart Laboratories, Inc. demonstrated the presence of PCBs in the delta region around the discharge pool. The location of these samples is given in Figure 6-3. Data for these samples as well as the 1982 samples collected by SLI are tabulated in Table 6-3. The 1980 samples were collected by driving 2-inch diameter aluminum tubes into the sediments.

Table 6-2. Summary of Peripheral PCB Distribution

Sample	Depth (cm)	Concentration PCB, ppm			Percent Aroclor		Pattern Alteration
		Aroclor 1254	Aroclor 1260	Total PCB	1254	1260	
D1	32	0.25	0.10	0.35	71.	29.	No
D2	32	0.11	0.06	0.17	67.	33.	No
E1	160	75.	35.	110.	68.	32.	Partial†
E2	80	4.8	8.2	13.	37.	63.	Partial†
F1	42	3.	29.	32.	9.1	91.	No
F2	96	85.	45.	130.	65.	35.	Yes
F3	48	140.	220.	360.	39.	61.	Yes
G	48	132.	78.	210.	63.	37.	Yes
H	62	442.	218.	660.	67.	33.	Yes
I	46	73.	187.	260.	28.	72.	Partial†
J	192	122.	68.	190.	64.	36.	Partial†
K	16	85.	35.	120.	71.	29.	No
L	48	83.	67.	150.	55.	45.	No
M	96	58.	52.	110.	53.	47.	No

† Pattern alteration was observed in subsurface sediments only.



SAMPLE DESCRIPTION

2	Brown Sand and Gravel
6	Silt, Black Sand
7	Black Pebbles, Gravel, Cinders
8	Silt, Black Sand
9	Black Organic Muck
10	Silt, Black Sand, Gravel

Figure 6-3

Locations of Additional Core Samples at Discharge Point 001A, Silver Lake

Table 6-3. Special PCB Distribution Study -

Discharge Point 001A

Sample	Depth (cm)	Concentration PCB, ppm			Percent Aroclor		Pattern Alteration
		Aroclor 1254	Aroclor 1260	Total PCB	1254	1260	
2	48	1400.	380.	1780.	79.	21.	Yes
6	54	58.	119.	177.	33.	67.	No
7	46	745.	<200.	745.	100.	0.	No
8	62	72.	158.	230.	31.	69.	No
9	54	72.	65.	137.	53.	47.	No
10	88	5200.	270.	5470.	95.	5.	No
N1	32	12.	0.60	13.	92.	8.	No
N2	32	350.	49.	399.	88.	12.	Yes
N3	32	31.	41.	72.	43.	57.	Yes
N4	32	112.	60.	172.	65.	35.	Yes
N5	16	130.	110.	240.	54.	46.	Yes

6.5 PCB Transport Considerations

The discharge from Silver Lake into the Housatonic River was sampled for three days during the April 1982 storm event. Data generated for this event are found in Table 6-4. Several significant observations can be made.

(1) No filterable PCBs were detected in the water-sediment mixture at any time during the event.

(2) The concentration range of detectable PCB in the water-sediment mixture was 30 to 50 ppt. Three of the eight samples contained less than 30 ppt PCB.

(3) The total suspended solids of the discharge ranged from 4.3 to 12.8 ppm, with a mean concentration of 5.9 ppm.

(4) The PCB concentration in the suspended solids ranged from <2 to 9 ppm, with a mean concentration of 7 ppm for samples yielding positive PCB results of 7 ppm.

(5) The mean instantaneous discharge for the event was 5.2 ft^3/sec.

(6) Total PCB discharged during the three-day period was less than 2 grams.

It is significant to note than in over 80% of the Silver Lake sediments examined, Aroclor 1254 is the predominate PCB present. This is the reverse of the situation in the Housatonic River, where Aroclor 1260 accounts for approximately 90% of the PCB load. Two additional observations point toward minimal discharge of PCB from Silver Lake into the river -- the results for sample F-1 from the Silver Lake discharge channel and sediment sample AA 4778 taken two feet from the Silver Lake discharge into the Housatonic River(See Figure 6-4). Both samples show Aroclor 1260 to be the predominate PCB present.

F-1: Aroclor 1254 = 3.0 ppm   Aroclor 1260 = 29. ppm

AA 4778: Aroclor 1254 = Not Detected   Aroclor 1260 = 7.3 ppm

Table 6-4. PCB Discharge from Silver Lake (April 1982 Storm Event)

Date/Time	Instantaneous Discharge ft^3/sec	Nonfilterable Suspended Solids (ppm)	Suspended Solids Discharge (tons/day)	Nonfilterable PCB in Water-Sediment Sample (ppb)	PCB in Suspended Solids (ppm)	Filterable PCB in Water-Sediment Sample (ppb)	Estimated PCB Transported (lbs/day)	(gm/day)
4/22/82 6:45p	5.97	5.5	0.09	0.05	9.	B.D.[1]	0.002	0.74
4/22/82 7:00p	5.97	5.7	0.09	0.04	7.	B.D.[1]	0.001	0.57
4/23/82 8:50a	5.21	12.8	0.18	<0.03	B.D.[2] (<2)	B.D.[1]	None Detected	
4/23/82 9:30a	5.21	10.2	0.14	0.04	4.	B.D.[1]	0.001	0.51
4/24/82 8:30a	4.64	4.3	0.05	0.04	9.	B.D.[1]	0.001	0.41
4/24/82 8:40a	4.64	4.3	0.05	<0.03	B.D.[2] (<7)	B.D.[1]	None Detected	
4/24/82 8:20p	4.16	4.3	0.05	<0.03	B.D.[2] (<7)	B.D.[1]	None Detected	
4/24/82 8:30p	4.16	4.5	0.05	0.03	7.	B.D.[1]	0.001	0.32

B.D.[1] = Below Detection. The detection limit for PCB in the water-sediment samples is 0.03 parts per billion.

B.D.[2] = Below Detection. The detection limit for PCB in the suspended solids (nonfilterable residue) samples varies as a function of the total residue present.

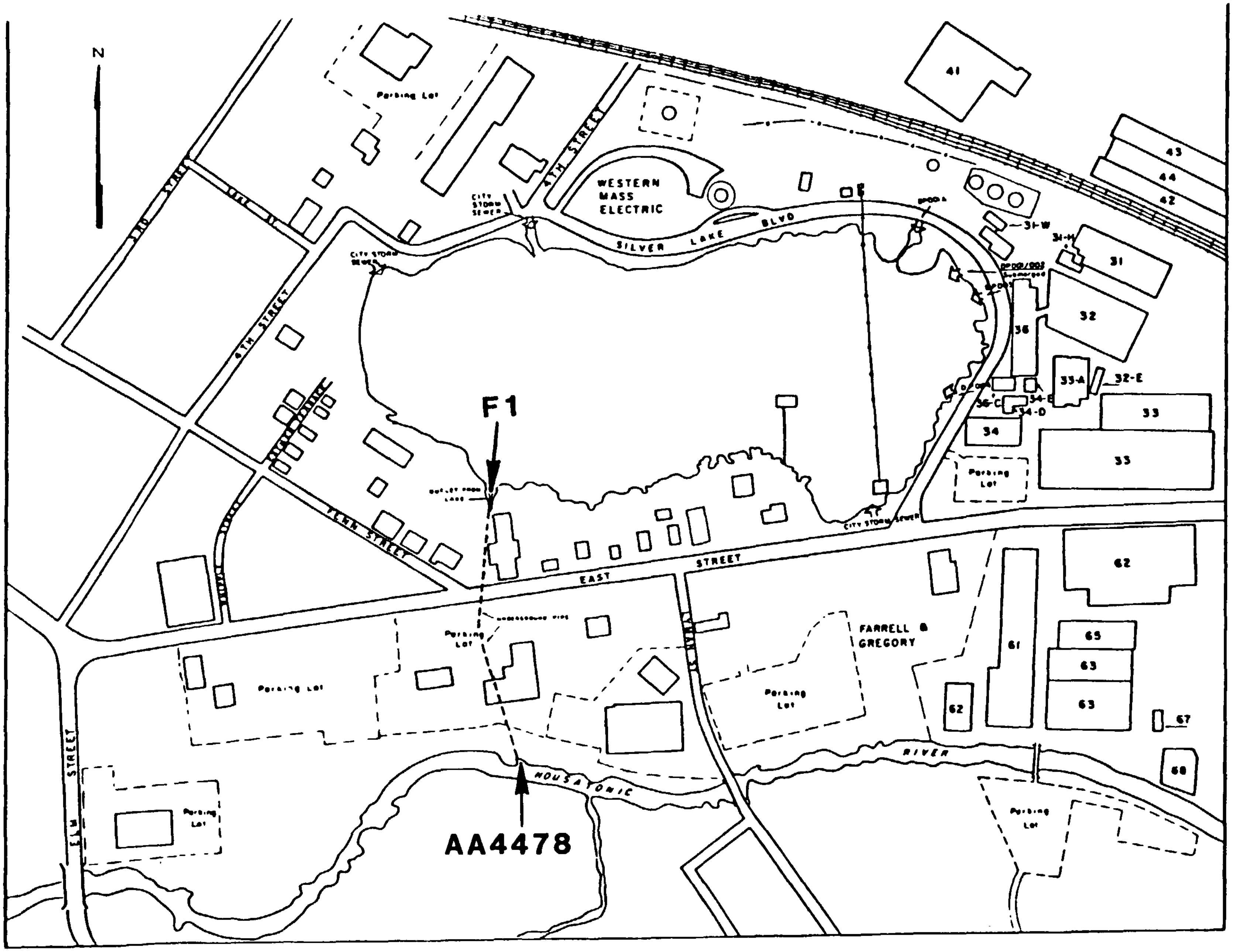


Figure 6-4
Silver Lake Discharge Sediment Samples

6.6 Summary and Conclusions

6.6.1 Summary.

This investigation has determined the level and distribution of PCBs in the bottom sediments of Silver Lake. As stipulated in the Consent Order, all measurements of PCBs in sediments are on a dry weight basis. Based on this study, the estimated quantity of Aroclor 1254 and Aroclor 1260 in Silver Lake is 63,600 pounds. The calculated amount of PCB located in the vicinity of the GE outfalls is approximately 30,000 pounds. Although PCBs are present in Silver Lake discharge from the lake into the Housatonic River appears to be minimal at this time. The depth of the lake and its quiesent discharge make it an effective trap for its PCB load.

6.6.2 Conclusions.

Conclusions which can be drawn from this study follow:

(1) The bottom sediments of Silver Lake contain PCBs.

(2) There is negligable discharge of PCBs from Silver Lake into the Housatonic River.

SECTION SEVEN

POLYCHLORINATED DIBENZOFURANS (PCDF) IN SELECTED FISH AND SEDIMENT

7.1 General

The terms and conditions of the May 25, 1981, Consent Order Agreement require the analysis of three sediment and four fish samples from Massachusetts and two fish samples from Connecticut for PCDF.

7.2 Program Description

Sample collections for this program were the responsibility of Stewart Laboratories. Analyses for PCDFs are to be carried out by Professor Christopher Rappe of the University of Umea in Sweden.

7.3 Program Completion Schedule

Stewart Laboratories completed its part of the program responsibilities when the samples were delivered to Dr. Rappe on September 23, 1982. The analyses are scheduled for completion in the first quarter of 1983, and a separate report will be issued for this study at that time.

SECTION EIGHT

CONNECTICUT FISH AND SEDIMENT INVESTIGATIONS

8.1 Background

The Consent Order (Docket No. 81-964) between GE and the EPA dated May 26, 1981 provides for a study of PCB contamination in the 9-mile portion of the Housatonic River in Connecticut designated by the Connecticut Department of Environmental Protection as a "no-kill" section. The measures required for Connecticut include:

i. "testing and analysis of an appropriate number of fish from the river to determine levels of PCB concentration;

ii. if PCB levels in the fish studied pursuant to section i. above are found to exceed the FDA limit, testing and analysis of fish from fish hatcheries used to stock this 9-mile portion of the river; and

iii. if PCB levels in river fish both exceed 5 ppm and significantly exceed the PCB levels in hatchery fish, measures and timetables for sampling and analysis to determine whether PCBs in the bottom sediments of the river are a source of contamination of the fish."

When the timetable for the Connecticut study was developed, it became apparent that the step-wise sequence of events proposed in the Consent Order would present problems with the sample collection schedule. Consequently, all three program elements were integrated into the study plan without consideration of PCB level restrictions.

8.2 Collection Program Description

Sample collections for this program were divided into three operations: hatchery trout, river fish, and bottom sediments. Sample handling and quality control protocols are the same as those used in the Massachusetts collections (Appendix 3-3, Appendices 5-1 and 5-6).

8.2.1 Hatchery Trout Collections.

A representative of Stewart Laboratories, Inc. obtained samples of brown trout from three Connecticut hatcheries prior to the 1982 stocking of the 9-mile "no-kill" stretch of the Housatonic River. On April 9, 1982 fish from the Quinebaug and Burlington hatcheries were collected as the stocking trucks were being loaded. The actual stocking of fish in the 9-mile "no-kill" area was observed at this time.

Additional brown trout were collected on May 10, 1982. Small fingerlings were obtained from the Burlington hatchery and 24 fish were taken from the Davey hatchery.

8.2.2 Housatonic River Fish Collections.

Fish from the 9-mile "no-kill" region of the Housatonic River in Connecticut were collected in early August 1982. (See Figure 8-1 for collection locations). The collection was a joint effort between the Fisheries Unit of the Connecticut Department of Environmental Protection and Stewart Laboratories personnel. Electroshocking was performed by State of Connecticut personnel. Specimens were taken from seven collection sites as follow:

(1) Meadows Campground to Springhole
(2) Springhole to Flatts
(3) Flatts
(4) Cellar Hole
(5) Carse Brook Confluence
(6) Elms
(7) Furnace Brook Confluence

Figure 8-1 Connecticut Stations


Figure 8-1, Cont.
HOUSATONIC STATE FOREST
SHARON
West Cornwall
F
The Cobble
Green Mtn
Buck Mtn
5
Cellar Hole
4
G
3
Flatts
2
1
H
CHAMBERLAIN
I
CORNWALL
J
Bread Loaf Mtn
Cornwall Bridge
Silver
HOUSATONIC
Calhoun Corners
Bald Mtn
Dudleytown
MOUNTAIN
C O R N W A L L
Whitcomb Hill
A Sediment Samples
1 Fish Stations

A total of 94 brown trout and 74 smallmouth bass were collected by SLI personnel. The only fish species observed during the electroshocking which are normally utilized for human consumption were brown trout and smallmouth bass. A summary of fish collections from hatcheries and the Housatonic River stations is given in Table 8-1.

8.2.3 Bottom Sediment Collections.

Bottom sediments from 10 locations (Figure 8-1) in the 9-mile "no-kill" area of the Housatonic River in Connecticut were collected just following the river fish collections in August 1982. All samples were collected with a piston sampler. Analytical data for these samples are given in Section 8.4. Field data are contained in Appendix 8-4.

8.3 PCB Levels in Fish Collected from the Nine-Mile "No-Kill" Reach of the Housatonic River in Connecticut.

8.3.1 Analytical Data Evaluation.

Three composites (12 fish each) of brown trout and one composite of smallmouth bass were analyzed for PCBs. Brown trout composite number C6490 was composed of the largest fish from the seven collection sites and is representative of a "worst-case" situation; this composite had a PCB concentration of 6.5 ppm. Specific details for the fish included in this composite are given in Table 8-2. Brown trout composite C7635 was made up of fish which had been in the river for a period of four months before their collection. Fish in composite C7636 had been in the river for 16 months before collection. Complete field and

Table 8-1. SUMMARY 1982

CONNECTICUT FISH COLLECTIONS AND ANALYSIS COMPOSITES

LOCATION	BROWN TROUT	SMALLMOUTH BASS
QUINEBAUG FISH HATCHERY		
Analyzed	3	-
Archived	9	-
BURLINGTON FISH HATCHERY		
Analyzed	6	-
Archived	54	-
DAVEY FISH HATCHERY		
Analyzed	3	-
Archived	21	-
CAMPGROUND TO SPRINGHOLE		
Analyzed	4	2
Archived	14	13
SPRINGHOLE TO FLATTS		
Analyzed	3	2
Archived	9	-
FLATTS		
Analyzed	4	1
Archived	2	18
CELLAR HOLE		
Analyzed	6	1
Archived	9	17
CARSE BROOK CONFLUENCE		
Analyzed	6	2
Archived	12	1
ELMS		
Analyzed	8	2
Archived	5	11
FURNACE BROOK CONFLUENCE		
Analyzed	5	2
Archived	7	2

TOTALS:

HATCHERY TROUT	
Analyzed	12
Archived	84
RIVER TROUT	
Analzyed	36
Archived	58
SMALLMOUTH BASS	
Analyzed	12
Archived	62

Table 8-2.

BROWN TROUT - COMPOSITE NUMBER C6490

Sample No.	Total Length (mm)	Whole Body Weight (gm)	Origin (Hatchery)	Stocking Age(yr)	Stocking Date	Age at Collection (mo)	Approximate Time in River (mo)
Campground to Springhole Location							
5681	449	524.	HFFA Fish		Sp.'81		16
5683	366	496.	Quinebang, CT	1-2	Sp.'81	28 - 40	16
Springhole to Flatts Location							
5694	305	284.	Burlington, CT	2-3	Sp.'82	28 - 40	4
5700	356	405.	Quinebang, CT	1-2	Sp.'81	28 - 40	16
Flatts Location							
5709	318	306.	Burlington, CT	2-3	Sp.'81	40 - 52	16
Cellar Hole Location							
5710	357	434.	Burlington, CT	2-3	Sp.'81	40 - 52	16
Carse Brook Confluence Location							
5725	454	907.					
5737	394	709.	Quinebang, CT	1-2	Sp.'81	28 - 40	16
Elms Location							
5814	300	369.	Burlington, CT	2-3	Sp.'81	40 - 52	16
5820	337	420.					
Furnace Brook Confluence Location							
5827	324	340.	Burlington, CT	2-3	Sp.'82	28 - 40	4
5831	325	347.	Burlington, CT	2-3	Sp.'82	28 - 40	4

analytical data for all fish analyzed from the 9-mile "no-kill" area are found in Appendix 8-1. A data summary of PCB levels in fish is given in Table 8-3.

Table 8-3. PCB Levels in Connecticut Fish

Composite Number	Type Fish	Composite Description	# Fish in Composite	% Lipids	Total PCB (μg/g, wet tissue)
C6490	Brown Trout	Largest Fish	12	3.88	6.5
C7635	Brown Trout	4 Month Exposure	12	3.28	2.9
C7636	Brown Trout	16 month exposure	12	2.89	5.8
C6491	Smallmouth Bass	Unknown	12	0.44	1.1

No PCBs were found in any of the hatchery trout. From the above, it is clear that the PCB level in trout is a function of the length of time in the river. The average PCB level is thus a function of the trout residence-time distribution. Using the ages of the above composites and the archived fish as an estimate of this age distribution leads to a weighted average PCB concentration of about 3.8 ppm. Including the "worst-case" composite (C6490) raises this figure slightly to about 4.2 ppm, still beneath the 5.0 ppm criterion value. Archived brown trout and smallmouth bass are characterized in Appendix 8-2 and 8-3, respectively.

Table 8-4. PCB Levels in Hatchery Brown Trout

Sample No.	Identification	Length (mm)	Weight (gm)	% Lipids	Aroclor 1242 and/or 1016	Aroclor 1254	Aroclor 1260
	Quinebaug Hatchery--Collected 4/9/82						
4242	Brown Trout SL0010	260.	195.	2.79	ND	ND	ND
4243	Brown Trout SL0011	285.	270.	3.17	ND	ND	ND
4244	Brown Trout SL0023	280.	249.	4.50	ND	ND	ND
-	Comp. of above C3868	-	-	3.50	ND	ND	ND
	Burlington Hatchery--Collected 4/9/82						
4246	Brown Trout SL0025	275.	231.	4.78	ND	ND	ND
4247	Brown Trout SL0026	280.	245.	3.61	ND	ND	ND
4248	Brown Trout SL0027	275.	240.	5.51	ND	ND	ND
-	Comp. of above C3873	-	-	4.52	ND	ND	ND
	Davey Hatchery--Collected 5/10/82						
4250	Brown Trout SL7008	205.	112.	4.84	ND	ND	ND
4251	Brown Trout SL7009	205.	117.	4.32	ND	ND	ND
4252	Brown Trout SL7012	202.	102.	3.98	ND	ND	ND
-	Comp. of above C3876	-	-	4.53	ND	ND	ND
	Burlington Hatchery--Collected 5/10/82						
4254	Brown Trout SL7042	105.	15.	<0.1	ND	ND	ND
4255	Brown Trout SL7043	97.	12	<0.1	ND	ND	ND
4256	Brown Trout SL7044	120.	21.	<0.1	ND	ND	ND
-	Comp. of above C3880	-	-	<0.1	ND	ND	ND

ND = Non Detected

Detection Limits: Aroclor 1242 = 0.01 ppm
Aroclor 1254 = 0.02 ppm
Aroclor 1260 = 0.02 ppm

8.3.2 Condition of Trout Collected in Connecticut.

The brown trout from Connecticut collected for this study were evaluated for relative robustness (condition) by the manner described for the Massachusetts fish (Section 5.4). A total of 264 fish were examined. Results of the evaluation are found in Table 8-5.

Table 8-5. Condition of Connecticut Brown Trout

	Date Collected (1982)			
	4/9	5/10	8/5	8/6
HATCHERY	1.17 (24)	1.22 (72)		
STREAM			0.99 (69)	1.02 (25)

In general, the condition of brown trout compared favorably to that of records from several North American sources. One study from New York (NY State Hatcheries) recorded C values ranging from 1.06 - 1.45. Highs for condition factors were reported during spring and summer months. Carlander (1969) states that tagged trout have lower condition than untagged trout, resident trout have higher condition factors than stocked trout which have been in the river for a time, and stocked trout lose condition after stocking. This last statement is evidenced by a comparison of condition for hatchery and river trout reported in Table 8-4. The longer body conformation with a larger head is further evidence of decreased condition of some brown trout in the study area of the river. The native brown trout found in the river in Massachusetts show higher condition (1.13-1.54) than the fish in the 9-mile "no-kill" area of Connecticut (0.99-1.02).

8.4 PCB Levels in Bottom Sediments of the Housatonic River in the 9-mile "No-Kill" Area in Connecticut

Bottom sediments in the study area in Connecticut are very scattered and sparce. A total of 11 samples from 10 locations were analyzed for PCBs. Results of these determinations are given in Table 8-6. Based on the data from this investigation, it is unlikely that PCBs in the bottom sediments of the river are the direct source of contamination in the fish.

Table 8-6. PCB Levels in Bottom Sediments from 9-Mile "No-Kill" Area in Connecticut

		PCB Concentration, ppm		
Location	Depth (cm)	Aroclor 1254	Aroclor 1260	Total PCB
Station A	0-16	B.D.	0.07	0.07
Station A	16-20	B.D.	B.D.	B.D.
Station B	0-8	B.D.	0.12	0.12
Station C	0-16	B.D.	B.D.	B.D.
Station D	0-6	B.D.	B.D.	B.D.
Station E	0-12	B.D.	B.D.	B.D.
Station F	0-12	B.D.	B.D.	B.D.
Station G	0-3	B.D.	B.D.	B.D.
Station H	0-4	B.D.	B.D.	B.D.
Station I	0-3	B.D.	B.D.	B.D.
Station J	0-16	B.D.	B.D.	B.D.

B.D. = Below Detection. The detection limit for Aroclor 1254 and Aroclor 1260 in sediments is 0.02 parts per million, respectively.

8.5 Summary and Conclusions

8.5.1 Summary.

This study has established the PCB levels in brown trout and smallmouth bass taken from the 9-mile "no-kill" area of the Housatonic River in Connecticut. The investigation has also determined the extent and level of PCB contamination of bottom sediments of the study area.

8.5.2 Conclusions.

The following conclusions can be reached based on this study:

(1) A definite correlation exists between PCB levels in brown trout and size and length of time in the river. The average PCB concentration in trout is thus a function of the residence-time distribution; calculations based on this distribution indicate that this average is below 5 ppm.

(2) The brown trout in the Housatonic River in Massachusetts are in better condition than the trout in the 9-mile "no-kill" area in Connecticut even though the level of PCB in the bottom sediments of Massachusetts are significantly higher than those in Connecticut.

(3) No PCBs were detected in any of the trout obtained from the three Connecticut hatcheries.

(4) The level of PCB in smallmouth bass, 1.1 ppm, is well below the FDA limit of 5 ppm in fish sold for human consumption.

(5) The level of PCB in the bottom sediment of the 9-mile "no-kill" region of the Housatonic River is considered to be a typical background level for rivers in Connecticut (Frink, 1978).

REFERENCES

Carlander, K.D. 1969. Handbook of Freshwater Fishery Biology. Vol.1. The Iowa State University Press, Ames, Iowa. 752 pp.

Frink, C.R. 1978. Distribution of PCBs in sediments. Connecticut Academy of Science and Engineering, Hartford, CT. 5 p.

New York State Hatcheries, no date. Constants for Trout in New York State Hatcheries, Mimeo. table.

SECTION NINE

QUALITY ASSURANCE/QUALITY CONTROL

9.1 Background

The complete laboratory quality control program for this project is described in the "Housatonic River Study Proposal" submitted to the USEPA and the Massachusetts DEQE in June 1981. This section reviews highlights of the program and presents the QA/QC data generated through the implementation of the plan.

9.2 Overview

SLI is keenly aware of the important role played by quality assurance in the generation of valid analytical data. Over the years, a QA/QC program has developed which documents and maintains rigid controls on instruments, equipment, reagents, supplies, sample collectiosn, and analyses. The total analytical program of SLI is routinely challenged with standards, duplicate samples, and inknown check samples.

The QA/QC program of SLI addresses areas including:

(1) QA/QC organization and responsibilities

(2) QA objectives for measurement data in terms of precision, accuracy, completeness, representativeness, and comparability

(3) Sampling procedures

(4) Sample custody and handling procedures

(5) Calibration procedures and frequency

(6) Analytical procedures

(7) Data analysis, validation and reporting

(8) Internal quality control checks and frequency

(9) Performance and system audits and frequency

(10) Preventive maintenance procedures and schedules

(11) Specific procedures to be used to routinely assess data precision, accuracy, and completeness of specific measurement parameters involved

(12) Corrective action

(13) Quality assurance reports on management

9.3 Quality Control Program Description

Major elements of the plan follow.

9.3.1 Routine Quality Control Procedures.

Applicable quality control procedures associated with the routine intralaboratory program of Stewart Laboratories, Inc., applied to all analyses performed for this project. This includes such items as:

(1) Deionized water was continuously monitored by a conductance method to assure that ASTM Type II grade reagent water wast used for all analytical procedures.

(2) Analytical balances were checked against reference weights (NBS Class S) on a once-a-month schedule.

(3) Only NBS Class A volumetric glassware was used.

(4) Glassware was checked for cleanliness and for detergent removal before each analysis run.

(5) Chemicals were dated upon receipt of shipment and replaced as needed or before shelf life was exceeded.

(6) Current service contracts and/or routine in-house main tenance and calibration programs were in effect on balances, gas chromatographs, gas chromatograph/mass spectrometers, recorders, and water purification systems.

9.3.2 Custom Laboratory QC Program for Housatonic River Project.

In addition to the routine quality control procedures given above, a custom program was designated for this project. This internal quality assurance program--administered jointly by the Laboratory Director and the Field Quality Control Coordinator--included blind splits of 10% or more of the actual samples (replicate analyses), blind random analyses of standard reference materials, replicate (every tenth sample analyzed) analyses of an appropriate instrument calibration standard for control chart data, verification by GC/MS of both qualitative and quantitative data for selected samples, and analysis of field travelers as process blanks. Special daily control and corrective action requirements were enforced for the entire project.

9.3.2.1 Daily Controls. The following operations were performed on a daily basis:

(1) A new calibration curve, composed of a minimum of a reagent blank and three standards, was prepared each time samples were analyzed. Agreement with the previous calibration curve was within ±10%.

(2) When 20 or more samples per day were analyzed, the working standard curve was verified by running an additional standard at or near the MCL every 10 samples. Checks were within ±10% of the original curve.

(3) A known reference sample (SRM) was analyzed with each analysis run. The measured value shall be within the control limit established by the SRM.

(4) Reagent blanks were performed for at least each batch of samples analyzed or whenever a new container of reagent or solvent was used.

(5) Linearity of standard response was established daily for PCBs of interest.

(6) A record was maintained of the retention times for each known PCB, using data gathered from spiked samples and standards. The average retention time for each PCB and the variance encountered for the analysis was calculated daily. If individual PCB retention times varied by more than 10% over an eight-hour period or did not fall within 10% of the established norm, the system was "out of control." The source of retention time variation was corrected before acceptable data were generated.

9.3.2.2 Corrective Action. No "out of control" periods occurred during the analyses associated with this project; therefore, no corrective actions were required. As an example, Appendix 9-1 is a listing of field control jars for 1980. All analyzed as below detection.

9.4 Quality Control--Split Sample Results

The actual PCB data generated in support of the internal field and laboratory quality control program are given in the following Appendices:

Appendix 9-2, 1980 River Sediment Splits
Appendix 9-3, 1982 River Sediment Splits
Appendix 9-4, 1980 Fish Splits
Appendix 9-5, 1982 Fish Splits
Appendix 9-6, 1982 Silver Lake Sediment Splits
Appendix 9-7, 1980 Plant Splits

9.5 Special External QC Activity

A split sample program, sponsored by EPA, was conducted using fish collected from Woods Pond and the nine-mile "catch and release" area of the Housatonic River in Connecticut. Final results submitted by SLI to EPA are shown in Appendix 9-8. Stewart Laboratories prepared the homogenates and released chain of custody for transfer to other participating labs with an EPA observer present.

9.6 Summary and Conclusions

The proposed laboratory quality control program was followed throughout the entire study. The data from this program provide confirmation of the validity of the sampling and analyses as required pursuant to the Consent Order.

SECTION TEN

SUMMARY AND CONCLUSIONS

10.1 Summary

The Housatonic River Study has met the objectives of the project; namely,

(1) the distribution and concentrations of PCBs in the bottom sediments of the Housatonic River and Silver Lake have been determined;

(2) the transport of PCBs within the river system has been evaluated;

(3) the concentration level of PCBs in fish, frogs, and other aquatic life normally utilized for human consumption have been established, and

(4) the PCB concentration level has been defined for samples related to the 9-mile "no-kill" region of the Housatonic River in Connecticut including bottom sediment, fish, and fish from hatcheries used for stocking.

In addition, selected fish and sediment samples have been collected and transmitted to the University of Umea, in Sweden for PCDF analyses.

The complete investigation covered the time interval from Spring 1980 through Fall 1982. As the result of this study, baseline data now exist from which river quality improvements can be monitored and evaluated. It should be noted that without the use of analytical methodology with part per trillion detection capabilities, much of the transport data would not have been acquired. A summary of the more relevant findings for each program unit is now presented.

HOUSATONIC RIVER BOTTOM SEDIMENT EVALUATION

(1) The extent and quantity of PCB contamination in bottom sediments from Dalton, Massachusetts to the Connecticut state line was determined. Based on this survey, the estimated quantity of PCB in the Housatonic River in Massachusetts is 39,400 pounds. Ninety percent of this amount occurs in the 12.5 mile region of the river between the GE plant and Woods Pond Dam. No apparent correlation was found to exist between sediment particle size and PCB concentration in the bottom sediments of this area.

(2) The major repository for PCB is the 5.3 mile stretch of river and backwaters from New Lenox Road Bridge to Woods Pond Dam. Approximately 68% of the PCBs in the Housatonic River are located in these two stations. The 520 acres of wetland floodplain above Woods Pond and Woods Pond itself with its profuse plant growth have both served as traps to limit migration of PCBs downstream of Woods Pond Dam. The decrease in concentration of PCBs in the top two inches of sediment appears to indicate a covering over of contaminated sediment in certain areas of river backwater and Woods Pond.

(3) The dilution effect due to the influx of uncontaminated sediment is very apparent in the river downstream of Woods Pond Dam. Natural burial of PCB-laden sediments is occurring in the river below Rising Pond Dam.

(4) Two reaches of the river, upstream of the GE plant and from Rising Pond Dam to the Connecticut state line, have an average PCB concentration of <1 ppm. These two sections, which represent 30.23 river miles or 48.6% of the study area, contain less than 2% of the PCBs found in the Housatonic River in Massachusetts.

(5) The balance of the PCBs in the river (~8%) are located in the area between Woods Pond Dam and Rising Pond Dam, a 19 mile reach. In this region, the majority of the PCBs (~75%) are contained in the reservoirs behind the Monument Mills Dam at Glendale and Rising Pond Dam. The average PCB concentration of the sediments in this section of river is 3.1 ppm.

(6) The PCBs are not uniformly distributed throughout the sediment. Although sediment depths range from 6 inches to 10 feet, the bulk of the PCBs are found in the top 32 cm (~1 ft.) of the sediment. Upstream of Woods Pond Dam, over 80% of the PCBs are present in the first foot of sediment.

SILVER LAKE BOTTOM SEDIMENT STUDY

(1) The estimated load of Aroclor 1254 and Aroclor 1260 in Silver Lake is 63,600 pounds.

(2) The variation of both PCB content and distribution in the bottom sediment of Silver Lake is extreme. However, approximately 95% of the total load is located in the top two feet of sediment.

(3) Although Silver Lake contains significant amounts of PCBs, discharge of PCBs from the lake into the Housatonic River appears to be minimal. During the April 1982 storm event, the maximum PCB concentration measured in the discharge was 50 ppt. The depth of the lake and its quiesent discharge make it an effective trap for its PCB load.

SUSPENDED SOLIDS AND PCB TRANSPORT STUDY

(1) Three bridge locations were chosen as transport study sites. They are the Schweitzer Bridge just downstream of Woods Pond, the inflow site; the Division Street Bridge near Great Barrington, the site of a USGS gaging station; and Andrus Road Bridge near the MA/CT state line, the outflow site.

(2) Suspended solids and PCB transport were studied on three occasions in the first quarter of 1982. The three streamflow conditions investigated represented typical winter background, snow-melt, and high-flow periods when river discharge was approximately equal to the mean annual high flow.

(3) Three transport modes were observed in PCB movement in the Housatonic River. Specifically, PCB transport accompanies the movement of the following vehicles:

i. PCB-laden, nonfilterable suspended sediments resuspended from bottom deposits;

ii. discrete non-sediment PCB-contaminated materials; and

iii. filterable PCBs in the water column.

One or more of these modes may occur simultaneously; however, the major mode of PCB transport is that associated with the deposition, resuspension, and redeposition of fine-grained particles containing sorbed PCB.

(4) At discharge rates of up to 350 ft^3/sec for the Housatonic River at the Schweitzer Bridge, PCBs are transported by the movement of discrete, non-sediment materials out of the Woods Pond area. This transport mode predominates for 75% of the flow duration. Transport by means of bottom sediment resuspension occurs at flows greater than 350 ft^3/sec. Although transport by means of bottom sediment resuspension is effective for only 25% of the streamflow duration, the largest

mass of PCB movement occurs by this mode.
Movement of PCBs in the filterable fraction of the water column is superimposed upon sediment resuspension transport for the upper 12% of the streamflow duration. Transport of PCBs out of Woods Pond is influenced, in an unpredictable yet significant way, by the random operation of the sluice gates which allows flow to by-pass Woods Pond Dam during periods of streamflow less than 700 ft^3/sec, or for ~90% of the streamflow duration.

(5) The major PCB transport mechanism observed at the Division Street Bridge near Great Barrington is associated with bottom sediment resuspension. Transport by this mode is projected to occur at flows greater than 800 ft^3/sec, which represents a flow duration of 20 per cent. Filterable PCB transport occurs simultaneously with sediment resuspension transport at flows greater than 1750 ft^3/sec, or a streamflow duration of 4 percent. No detectable PCB movement is anticipated at the Great Barrington site 80% of the time.

(6) The predominant transport mechanism observed at the Andrus Road Bridge

site was nonfilterable PCB movement associated with the resuspension of bottom sediments. This mode is in effect with stream discharges greater than 1300 ft^3/sec, which represents a streamflow duration of 20%. Transport by means of filterable PCBs in the water column occurs

only for a streamflow duration of 1% of the time and is associated with flows in excess of 4000 ft^3/sec. For 80% of the time, no detectable PCB transport is projected at this site.

(7) Maximum PCB transport at all three sites occurred during a period of high flow associated with a storm event.

(8) PCB transport past Great Barrington and Andrus Road Bridge is discontinuous and erratic and is associated primarily with high streamflow events.

(9) The Woods Pond area is not the sole source for all nonfilterable PCBs transported in the Housatonic River in Massachusetts. In fact, the primary source of nonfilterable PCB between the Schweitzer and Great Barrington sites is the bottom sediments of the impounded reaches of this portion of the river.

(10) Suspended-solids discharge at the transport sites is estimated to be four tons per day at Schweitzer Bridge, 32 tons per day at Great Barrington, and 113 tons per day at Andrus Road Bridge.

(11) The maximum suspended PCB discharge at each station is estimated to be seven pounds per year at Schweitzer Bridge, 70 pounds per year at Great Barrington, and 33 pounds per year at Andrus Road Bridge. These estimations are based on traditional statistical computations which assume PCB transport under all streamflow conditions. Experimental data from this investigation indicate that PCB transport at low streamflow conditions is negligible.

MASSACHUSETTS FISH STUDIES

(1) The Massachusetts fish studies have established the PCB level in fish, frogs, and other aquatic life normally utilized for human comsumption.

PCBs were detected in fish from all stations; however, only background levels were found in the control station (Station F1A). Fish with the highest levels of PCB were found in the reach of the river which contains approximately 90% of the sediment PCB load.

(2) The use of gill nets and electroshocking techniques, in addition to conventional angling, resulted in the collection of larger specimens for the 1982 study. Consequently, the PCB levels are somewhat higher than those found in the 1980 fish.

(3) Although there are selected areas of high fish population densities, much of the Housatonic River in Massachusetts is not very productive for fish species normally used for human consumption.

(4) Fish collections for both 1980 and 1982 (721 specimens) were evaluated as to their relative robustness so that a comparison could be made with similar species in other parts of the country. Based on this comparison, the condition of the four major game fish populations in the river in Massachusetts (sunfish, perch, bass and trout) are rated as good to excellent.

(5) Sunfish and perch have a relatively constant concentration of PCBs in their tissue regardless of their river habitat. The mean PCB concentration for all fish stations is 2.9 $\pm$ 0.9 ppm for sunfish and 3.3 $\pm$ 1.3 ppm for perch. Both of these levels are below the 5.0 ppm FDA limit for PCB levels in edible fish tissue.

(6) Trout are the most effective concentrators of PCB of all fish species examined. The PCB concentration in trout ranged from 3.3 to 240 ppm and was closely correlated with the PCB level of the sediment.

(7) PCBs have not accumulated to any significant degree in the aquatic vegetation of the Housatonic River.

(8) The PCB level of frogs from Woods Pond is significantly below 5.0 ppm, the FDA limit for human consumption.

CONNECTICUT FISH AND SEDIMENT INVESTIGATIONS

(1) This study has established the PCB levels in brown trout and smallmouth bass taken from the 9-mile "no-kill" area of the Housatonic River in Connecticut. PCBs were found in both species; however, the levels in trout are higher than the level in smallmouth bass.

(2) No PCBs were detected in any of the hatchery fish used in stocking the river study area. Fish from three hatcheries--Quinebang, Burlington, and Davey--were examined.

(3) A definite correlation exists between PCB levels in brown trout and size and length of time in the river. The average PCB concentration in trout is thus a function of the residence-time distribution; calculations based on this distribution indicate that this average is below 5 ppm.

(4) The level of PCB in smallmouth bass, 1.1 ppm, is well below the FDA limit of 5 ppm in fish sold for human consumption.

(5) The distribution and concentration of PCBs in bottom sediments was determined. Only 18% of the samples contained detectable levels of PCBs. The maximum concentration found was 120 µg/kg. This level of PCB is considered to be a typical background level for rivers in Connecticut.

(6) Bottom sediments in the 9-mile "no-kill" reach of the Housatonic River in Connecticut are very scattered and extremely thin and sparce. PCBs at very low levels were found in two of the ten sediment sampling stations.

QUALITY ASSURANCE/QUALITY CONTROL

(1) A quality assurance program, specifically designed for this study and covering both field and laboratory operations, was in effect for the entire project.

(2) Results from this program provide a measure of the validity and reliability of the data generated by these investigations.

10.2 Conclusions

The segments of the May 26, 1981 Consent Order assigned to Stewart Laboratories, Inc., have been completed. As the result of these investigations, a scientifically developed data base now exists which provides a measure of comparison for monitoring and evaluating river quality changes.

This study provides a basic understanding of the overall magnitude of the environmental instrusion of PCBs into the entire river system. Pertinent observations for each study unit are contained in the summary portion of this section. The sheer magnitude of the study makes it difficult to single out the most relevant conclusions; however, two findings warrant further discussion. These observations come from the bottom sediment investigation (Section 3) and the PCB transport study (Section 4). They are:

(1) contrary to previous predictions, the primary repository for PCBs in the Housatonic River in Massachusetts is the 12.2 mile reach between the GE plant and the headwaters of Woods Pond, not Woods Pond itself; and

(2) very little PCB (<10 pounds per year) is being transported out of Woods Pond.

These observations lead to the conclusion that very little PCB movement is occurring in the area of the river which contains 90% of the PCBs in Massachusetts, namely the 12.5 miles between the GE plant and Woods Pond Dam. A further indication of slow movement relates to the 40 year deposition period associated with PCB use between the early 1930's and the early 1970's.

Two factors that probably have a bearing on this limited movement are the particle size distribution of the sediments and the presence of a large floodplain area between New Lenox Road Bridge and the headwaters of Woods Pond (Station 17). This study has established that at least 90% of the sediment particles between Stations 9 and 16 are medium to fine grained sand particles which are >62 microns in diameter. Sediments of this size are not normally transported for great distances as suspended sediments.

The second factor relating to sediment movement involves the effects of Woods Pond Dam on stream flow velocity. These effects become apparent a short distance below New Lenox Road. During periods of high flow, the water backs up from Woods Pond and forms coves and bays off the main stem. As the river returns to average flow conditions, the normal banks, which are breached at high flow, prevent the backwater from completely draining back into the river resulting in the production of stagnant pools. This probably accounts for the presence of 13,000 pounds or 33% of the total PCB load in this backwater region.

In conclusion, the Housatonic River Study represents an in-depth, integrated assessment of the overall magnitude of the PCB situation in the entire river system in Massachusetts. Specific areas needing further monitoring and additional study can now be defined.